AGRICULTURE

MURBY'S "SCIENCE AND ART DEPARTMENT" SERIES OF TEXT BOOKS.

PRINCIPLES OF AGRICULTURE:

EXPRESSLY ADAPTED

TO

THE REQUIREMENTS OF THE SYLLABUS

OF THE

SCIENCE AND ART DEPARTMENT, SOUTH KENSINGTON.

BY ALBERT CAREY,

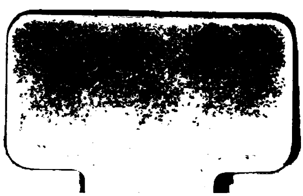
Medallist and Holder of First Class Honours Certificate; Head Master of the Board Schools, North Tawton.

London:

THOMAS MURBY,

32, BOUVERIE STREET, FLEET STREET, E.C.

1880.



PAGE

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

PRINCIPLES OF AGRICULTURE.

CHAPTER I.

1. Soils.—The routine of operations by which vegetable food is produced from the earth is commonly known as Agriculture (*ager*, a field) or Horticulture (*hortus*, a garden), according as it relates to the field or the garden. The great object of such cultivation is to raise on any given space the greatest quantity of certain kinds of vegetation, with a due regard to the quantity of the produce, at the cheapest rate, and without unduly taxing the energies of the soil.

By the *soil* is meant the surface of the land, consisting of earthy matter of various degrees of fineness.

All fertile soils are composed of two classes of ingredients—organic and inorganic.

The Organic (Gr. *organon*, a member) is derived from animal and vegetable substances.

The Inorganic substances are the mineral constituents of the soil, and are usually said to be derived from the decay or disintegration (*dis*, asunder, and *integer*, whole) of the primitive or crystalline rocks, because these original rocks gave rise to all other varieties of rock formations.

The late Sir Charles Lyell gives the following minerals as chiefly composing the crystalline rocks:—Quartz, Felspar, Mica, Hornblende, Augite, and Zeolites.

Quartz forms the mass of silicious sand. It is found as a hard, six-sided crystal, and is composed of silicic acid, or pure silex.

Felspar is the most abundant in the mineral world, next to quartz. It is chiefly composed of silica, alumina,

and potash or soda. It is softer than quartz. The softer minerals occurring in granite are of felspar, and its decay is the immediate cause of the formation of clay.

Mica, from the Latin *mico*, I glisten, forms the glistening scaly crystals in granite. It is composed mainly of silica, potash, and magnesia. It is found in many sandstones, giving to them a silvery appearance, and is also very extensively distributed in rocks, and readily splits into brilliant thin plates elastic in texture.

Hornblende and Augite.—Hornblende (*blenden*, to dazzle) is a dark green or black mineral, consisting mostly of silica, magnesia, lime, and alumina. Its fracture has a horny, glistening appearance.

Augite is of a dark green colour; it contains silica, magnesia, lime, alumina, manganese, and protoxide of iron. Hornblende and Augite differ but slightly in form and mineral composition. The word Augite is derived from the Greek, and means "splendour."

Zeolites are composed of silica, lime, alumina, and water. They are easily decomposed into their component parts, and are found in the form of crystals, also in the cavities of trap rocks and ancient lavas.

From the foregoing particulars it may readily be recognized how intimate is the connection between some of the general principles of Geology and those of Agriculture.

Having noticed the chief substances in the composition of the primitive rocks, we proceed to consider the *agencies* which have decomposed them.

Had the exterior crust of the earth been subject to no modifying causes, the world would have been precisely the same in appearance as at the time of its creation. Such, however, is far from being the case. One continuous series of change and progression has been going on, occasioned by the incessant operations of the various forces in nature—the shivering of the earthquake and the upheaving of the volcano, together with the

universal operations of chemical and electrical agencies, being amongst the most direct and powerful in their action. The long continuance of these and other destructive agencies on the primitive rock may induce decay, and yield a soil, or the *débris* may, in course of time, through the agency of water, become hardened into stratified rock, or form beds of clay. These, by the out crop of their edges, and the exposure of part of their surfaces, like tiles upon the roof of a house, may combine to form the inorganic part of a cultivable soil with many of their original chemical properties.

There are three great agencies which thus pulverize Rocks—(1.) *The Atmosphere*, (2.) *Water, and* (3.) *Frost.*

(1.) *The Atmosphere.*—One hundred volumes of dry air under ordinary circumstances contain mechanically mixed, not chemically combined—

Nitrogen	79·12
Oxygen	20·80
Carbonic Acid	·04
Carburetted Hydrogen	·04
Ammonia	trace
	100·00

Many other substances are mixed with this proportion of dry air, aqueous vapour being the most important, and the others sulphuretted hydrogen, sulphuric acid, hydrochloric and nitric acids, ozone, the miasmata of marshes, and various gases liberated from volcanoes. The following bases are also found in varying quantities: —Potash, soda, lime, manganese, and iron; while others probably remain yet to be discovered.

(2.) *Water.*—Atmospheric air and water, or aqueous vapour, are mutually capable of absorbing and retaining each other, and in consequence the carbonic acid of the atmosphere is taken up by the aqueous portion in its

various forms of snow, rain, dew, fog, or mist in passing through the air, and reaches the surface of a rock, bathing it in a dilute solution of carbonic acid in water. In course of time this proceeding causes the hardest rock to part with its alkalies, and, gradually loosening the cohesion of parts, the various constituents moulder away in small particles.

(8.) *Frost or change of temperature* may be regarded as a mechanical phase of atmospheric agency, and under certain latitudes is an important modifying cause. During the winter the moisture between the particles of all rocky matter often becomes frozen, and, in this state of ice, expands and forces apart these particles. While the frost lasts the ice holds them together; but when the thaw comes, their cohesion being destroyed, they fall asunder, and offer a greater amount of surface for future pulverizing processes, and in this way, under all latitudes and in all altitudes where frost occurs, vast waste is every winter effected.

Every cliff and railway cutting, every *bare* sloping bank and ploughed field, shows the effect of the "weathering" power of frost.

2. Different kinds of Soils—Variations in their Composition, Texture, and Condition.—Soils may be divided into two great classes—(1.) *Soils in situ*, and (2.) "transported" soils.

(1.) *Soils in situ* are such as have been formed from the underlying rock. They consist largely of constituents identical with the parent rock, with the addition of vegetable matter derived from the decay of past vegetation. A rock once pulverised soon becomes fit to support the lower forms of vegetable life. Fungi and lichens are followed by mosses and grasses, and, as these decay, their remains increase the depth of the fertile layer and give rise to carbonic acid. This, in its turn, tends still further to dissolve and break up the rocky layer beneath,—a process which is undoubtedly supplemented by the

growing roots themselves. Soils *in situ* are also known as "sedentary" or "indigenous" soils. Examples are seen in the thin white soils of the Upper Chalk, the Clays of the Lias, the Clays of the Weald, and the Oxford Clays, together with the soils of the Lower Oolite, and Old and New Red Sandstone. Reference to a geological map of the country will show at a glance the large extent of sedentary soils overlying the parent rock, and partaking to a large extent of its special constituents.

(2.) *Transported Soils.*—These need not of necessity correspond in any important degree with the geological features of any given district where they may occur.

When we consider that the grinding glacier, the rolling river, the rushing flood, the molten lava, blinding clouds of ashes from the belching volcano, and even the mighty iceberg, may all have contributed to their formation, the varied nature of their particles will be fully accounted for, and cease to be a matter of surprise.

Glaciers are simply ice-rivers formed from the ever-collecting snow by pressure from above. As they slowly and with irresistible force descend the mountain gorges, they rend, and grind, and scarify the rocks, the resulting particles being carried down to a lower level by the ice-water ever trickling from their extremities as they press beyond the snow line.

Rivers may form deltas, as may be seen in the case of the Nile, the Mississippi, the Amazon, the Ganges, the Rhine, and many others. Alluvial flats may be formed on the site of a lake where a muddy mountain stream is depositing its sediment and filling up its bed. Lake Geneva in this way receives the muddy impurities of the Rhone, which issues from it a pure and sparkling stream.

Floods and Torrents, by their velocity, dislodge and bear away fragments of rocks and stones, the "attrition"

or friction wearing away their substance and deepening the water channel.*

Molten Lava finally cools, and in time crumbles slowly into a fine fertile clay, proof of which may be seen in the luxuriant vineyards and olive gardens of Sicily and Italy in the neighbourhood of Etna and Vesuvius. Even in our own country, in the north and extreme west, and in the neighbourhood of Edinburgh in Scotland, there are fertile soils overlying ancient fields of lava.

Volcanic Ashes are simply dust from volcanoes, this dust being nothing more than the very minute fragments of the matter sent out from within a crater. A great proportion consists of fragments of films coating the bubbles produced during the boiling up of the lava. This rises into the air a great height, being so abundant and light that it reaches into the upper currents of the atmosphere. The currents of wind sift it, as it were, and it becomes distributed in uniform beds, some of one size and some of another, over an area amounting sometimes to thousands of square miles. The cities of Herculaneum and Pompeii were, in A.D. 79, so completely buried in ashes and scoriæ as to be lost to sight and knowledge for nearly twenty centuries.

Icebergs.—During what is known as the "Glacial Epoch" a cold period must have set in, and the land in our latitudes and in the north of Europe undergone a submergence of some thousands of feet. During this period icebergs passed and dropped their burdens of boulders, gravel, etc., which afterwards appeared on the surface as the land became again elevated to its present

* "It has been computed that a velocity of 3 inches per second will tear up fine clay; that 6 inches per second will lift fine sand; 8 inches sand as coarse as linseed, and 12 inches fine gravel; while it requires a velocity of 24 inches to roll along rounded pebbles an inch in diameter, and 36 inches per second to sweep angular stones the size of a hen's egg." "Stones of ordinary specific gravity (from 2·5 to 2·8) lose more than a third of their weight when immersed in water"—*Prof. Ansted.*

level, causing another distribution of sea and land, and with this the glacial period passed away. During the gradual process of elevation, and as our islands appeared, glaciers and avalanches periodically descended, smoothing and "striating" the hills and valleys down which they passed, and leaving the *débris* as "moraines" of sand, gravel, or boulders.

We have seen, then, that soils are due to the disintegration of rocks which has been going on for ages; in the course of which time the country has been covered by a coating of earthy materials, varying in depth, composition, texture and condition, according to their origin and the agencies which have contributed to bring them together. Sandstone has produced a light, porous, sandy soil; slaty shale has yielded a cold stiff, impervious clay; from the crumbling limestone a calcareous soil has been formed; the soils resting on the chalk formation generally partake of a dry, loose, friable character, congenial to many of the most useful forms of vegetation, while these and many other varieties become occasionally so intermingled that soils are formed of most complicated composition, varying in texture and in condition, and often extremely fertile.

Peat.—This substance, of which bogs are composed, gives rise to a class of sedentary soils consisting almost entirely of vegetable matter, which often reaches as high as 97 per cent. It is a kind of humus produced by the accumulation of the remains, more or less decomposed, of herbaceous plants peculiar to mosses, which, growing and flourishing in wet places, have become blended with other substances through the agency of water.

Peat differs from ordinary vegetable mould in having had a different origin, and is a description of humus which specially requires intermixture with lime or potash to neutralize its acids, which are noxious to the better order of vegetation—the consequence of decomposition having taken place under water.

Peat soils occur only in moderate and high latitudes, its accumulation in hot countries being prevented by its rapid decomposition. Large tracts exist in the north of Europe and in Russia, Germany, and France. Ireland contains nearly three million acres of peat land, and it forms an important class of cultivated soils in our own country. Even in the same locality peat differs considerably in its constitution and qualities. The varieties are occasioned by the different degrees of moisture and temperature which have influence on its formation and growth, by the proportions and qualities of the earthy substances combined with the vegetable matters, and by the texture of the original plants converted into peat. Where large surfaces of peat occur, the natural drainage is interrupted, and the rays of the sun, instead of communicating heat to the soil, are expended in converting water into vapour.

3. Classification of Soils, as determined by Physical Condition and Chemical Composition.

Physical Conditions.—Soils are classified with reference to their character or physical properties, according to their texture or condition—a point on which they differ widely from each other.

They may be wet and consequently cold, they may be warm and dry, they may be friable and easy to work, or tenacious and difficult to cultivate.

The proximate ingredients of all soils are *sand*, *clay*, *lime*, *vegetable matter*, and *mineral fragments* (stones). Of these, sand and clay are the most important, and what is known as the physical analysis of soils is based upon the proportion of sand and clay which they contain. For instance, a soil which is classed as—

A Sandy Soil is one in which sand predominates.

A Clay Soil is one in which clay predominates.

A Loam is a soil containing about equal proportions of sand and clay.

A Sandy Loam contains about 75 per cent. of sand.

A Clay Loam contains about 75 per cent. of clay.

But, as in actual practice a soil seldom yields exactly these results, each should be classified with that to which its composition most nearly approaches. The manner in which this is determined is extremely simple. First, the stones and portions of rock are removed as not forming part of the soil proper. The fine earthy matter is then separated by sifting, and carefully dried and weighed. It is then mixed with water, thoroughly shaken and put to settle for a short time, when the sand will fall to the bottom. The finer particles still floating in the water are composed of clay, and after being poured off into another vessel are allowed to settle, and the water carefully removed. In this way the sand and clay may be separated, weighed, and compared.

Sand.—This varies in its composition according to the rock from which it is derived. If it contain minute particles of lime it is called calcareous sand (calx—lime). Sea-sand is occasionally rich enough in this respect (from its admixture with sea shells) to be used as a cheap substitute for lime, as in the neighbourhood of Bude on the north coast of Cornwall.

Silicious sand (*silex*, flint) is mainly composed of small grains of silicic acid, or silica. This substance forms a very large proportion of sandstone. and exists abundantly in granite and other crystalline rocks. It is seen in the purest form as "silver sand." Micaceous sand, containing mica, is another variety.

Sandy soils are loose, friable, open, and dry, and for that reason easily cultivated; but sand alone, from its extremely elementary nature, is unfit to support plant life. Its particles assist in keeping open the pores in a soil, thus facilitating the percolation of water, and the passage of roots in search of food. When charged with moisture, sand dries quickly, and readily absorbs and retains heat.

Clay is produced by the decomposition of felspar, or of almost any of the crystalline rocks. If this decomposition has gone so far that little remains besides the silicate and alumina, which are the chief constituents, the soil will be almost barren; but this is seldom the case. The silicate and the alumina are generally associated with potash, soda, lime, ferric oxide, magnesia, and carbon dioxide. These impurities render clay much more valuable as a constituent of soils than if it were pure. This fertility, however, is largely dependent upon the presence of a peculiar form of silicate of alumina, which, combining with lime, soda, potash, and ammonia, forms what are termed *double silicates*. In these double silicates part of the alumina has been replaced by an equivalent of lime, soda, potash, or ammonia, forming most valuable compounds, known as silicate of alumina and lime, silicate of alumina and soda, silicate of alumina and potash, and silicate of alumina and ammonia, further particulars of which will be given hereafter (26).

China clay and pipe clay are the purest forms in which clay is found. In structure it is crystalline. Its plasticity imparts a retentive character to a soil, enabling it to hold moisture, while its coolness enables it to resist drought. Alumina itself, which forms the basis of all clays, and to which its plastic property is owing, is not known to enter directly into the composition of any plant.

Marl is a mixture of lime and clay, breaking up into small, square-like masses when dry. It is found of various colours—red, grey, yellow, and blue—and varies much in quality. It has been known and used from the earliest ages, but its use is being greatly superseded by that of lime, a quicker and more efficient substitute.

From the nature of its composition it acts as a manure, and also has an important effect in altering the natural condition of the soil to which it is applied. Marls are

classified as "true marls," consisting mostly of calcium carbonate or carbonate of lime, and "clay marls," in which clay predominates. Some marls contain as much as from 80 to 90 per cent. of lime, others only 8 per cent.

Lime.—The use of lime dates from a very early period. It occurs as a constituent of all fertile soils in several forms, of which chalk, the pure carbonate of lime, is one of the most extensive formations in England, reaching in an irregular and almost continuous line from Flamborough Head in Yorkshire, to Sidmouth in Devon in one direction, and in another, to Margate and Dover in Kent, occupying a very wide extent in Wilts and Dorset, as well as some other localities. It is often of great thickness; in one instance, at Inkpen, about 1,100 feet. The upper portion, which contains flints, affords but a poor thin soil, which, however, becomes very available for turnips and barley. The lower oolite and magnesian and mountain limestones consist largely of lime, which is also found in the form of marbles in many other geological formations, so that it is available in nearly every district; its wide distribution being proved by the fact that it is found in all fertile soils in more or less abundance.

Lime contains a large amount of impurities, a circumstance which adds to its agricultural value, so that when associated with clay, the compound will consist of most of the elementary substances which enter into the composition of plants.

Vegetable Matter.—The name "humus" or "vegetable mould" is given to the organic matter, more or less decomposed, which gives to a rich soil its dark colour, and which constitutes so large a proportion of peaty deposits. If a quantity of soil be burnt, a portion of it will be dissipated and lost—this will be the organic part, formed from the remains of plants (and animals) which have grown, lived, and died, and left their remains upon the

soil, or been conveyed to the soil in the form of manure. This organic matter is always in a state of gradual decay, which continues till it is reduced to the condition of pure carbon. An excess or deficiency of this partially decayed matter is alike unfavourable to fertility; in the former case by rendering the soil too light for the retention of water, and in the latter from a deficiency of organic food required by plants, particularly in the earlier stages of their growth.

Mineral or Stony Fragments.—Wherever these occur in great abundance they tend materially to modify the character of the soil. The nature of these stony fragments depends on the origin of the soil of which they form a part. An alluvial, "transported" soil will contain water-worn fragments and rounded pebbles which have, perhaps, been carried down by some river and deposited in its estuary. In a "sedentary" soil, the fragments will be portions of the underlying parent rock, while in a soil composed of the disintegrated materials of various rocks we may expect the stony fragments to be equally diversified in their composition. All mineral fragments, under the influence of frost, warmth, and moisture, are gradually being reduced in size, and must finally mingle with, and form part of, the finer particles of the soil—a process only dependent, as to time, on the intensity of these forces.

It will thus be seen that the physical condition of soils is entirely due to the proportions in which sand, clay, lime, vegetable matters, and mineral fragments enter into their composition.

Chemical Analysis of Soils.—In addition to this physical analysis of the soil, the several ingredients of which it is composed are determined by chemical analysis. This process reveals the fact that a large number of different substances of varying proportions exist in the soil.

In itself the soil may be said to consist of two distinct

classes of bodies—the *inorganic* or *mineral* matters, and the *organic*, or that which once had life, either animal or vegetable. The organic constituents, as already mentioned, are termed humus. This is incapable of being directly absorbed by the plant, but is useful from its power of absorbing ammonia, soda, potash, lime, and magnesia, and thus preventing their being washed out of the soil; and, in the second place, from the effect which the carbonic acid, produced by its decomposition, has upon the mineral ingredients of the soil.

When a soil is exposed to the action of fire these two groups are separated, the organic matter being dispersed and the inorganic or "fixed" remaining. On examination the following are found to be the most important bodies usually found in cultivated soils, and are mostly to be met with as well in the crystalline rocks:—

Silica.	Phosphoric Acid.
Alumina.	Carbonic Acid.
Ammonia.	Sulphuric Acid.
Potash.	Magnesia.
Soda.	Oxide of Iron.
Lime.	Chlorine.

In analysing a soil it is necessary to determine (1) the organic constituents, (2) the substances soluble in water, (3) those insoluble in water but soluble in acids, and (4) those insoluble both in water and acids. Of the organic constituents, the plant generally contains much and the soil comparatively little. Upon the substances soluble in water the plant will generally depend for its nourishment. Of those substances insoluble in water but soluble in acids, the proportion is very variable, but usually forms about 10 per cent. of the whole. Of those insoluble both in water and acids the proportion is large, amounting generally to from 80 to 85 per cent. of the whole. It is highly important for the fertility of the soil, not only that certain

of its constituents should be in a soluble state, but that others should be capable of being readily made soluble, so that a supply of the essential elements of the plant may be constantly kept up. Even those portions of a soil generally stated as being insoluble are gradually being disintegrated, and thus form a source of the continued fertility of the soil.

4. Active and Dormant Constituents of the Soil.—The inorganic matter of a soil is distinguished according to its soluble condition. Those portions of a soil which are ready for use—that is, can be dissolved by the influence of rain water—are known as the *active* constituents; while those which are not ready for use, as not being soluble in rain water, are termed *dormant* (Lat. *dormio*, to sleep).

The former serve for the *immediate* use of vegetation, while the latter is the *storehouse* from which future supplies of fertility are drawn as the active constituents become exhausted and used up by the requirements of vegetation.

A distinct feature of good farming is the growth of heavy crops without unduly exhausting the active ingredients of the land, because the reserve supplies in a dormant condition are constantly undergoing the necessary change by judicious management.

The natural forces which change the dormant matter into the active condition are precisely similar to those which break up the rocks and stones to form a soil, viz., *frost*, *warmth*, and *moisture*.

The *frost* and *warmth*, by freezing and thawing alternately, break up the soil of a field roughly ploughed before winter into a fine condition. The carbonic acid and oxygen contained in the *rain water* so act upon the surfaces of these particles that some portions of them become *soluble in water* and ready to be taken into the circulation of a growing plant. If this demand on the land be continued without any return being made to

the soil, it is clear that the land will in time become exhausted, and consequently unproductive. To remedy this the land receives artificial supplies at the hand of man in the shape of manures of various kinds.

5. Conditions Regulating the Conversion from the Dormant State into an Active Condition, available for Cultivation.—We have seen what the influences are which combine to change the dormant parts of a soil into an active condition, but to enable these influences to work most effectually and quickly, certain mechanical operations are carried out by the farmer, enabling the process to be done in a much shorter period of time. These processes are known as the "cultivation" of the soil (Lat. *cultum*, to till). The operation is further assisted by the application of a certain class of manures which exert a chemical influence of a highly beneficial character.

The use of the plough to turn up the soil, the harrow to break it down, and the roller or crusher to reduce it to a state of fine division, completes the process of pulverization commenced by the frost, and allows the rain to percolate through it and carry out the necessary chemical operations by means of its contained carbonic acid and oxygen. This action is still further enhanced by the upward passage of water through the fine interstices by capillary attraction.

6. Chemical and Physical Conditions Regulating the Barrenness and Fertility of Soils.—Barrenness may result from various circumstances.

All fertile soils contain a number of inorganic substances (3), and if these be not present in sufficient quantity certain crops will not ripen in consequence. By far the greatest number of soils are poor in phosphoric acid; hence the great use of phosphates as fertilizers. Some contain too small a proportion of lime; hence the practice of liming and marling. Others possess too limited a supply of the alkalies, more particularly of

potash—especially is this the case with light sandy soils; hence the necessity for the application to them of large quantities of the alkalies before they can be made fit for the cultivation of root crops, the ash of which is peculiarly rich in potash. In other cases some of these substances may be present in excess, as is often seen with some of the lower compounds of iron, salt, and acrid organic matter, all of which prevent healthy vegetable growth.

The *physical condition* of a soil may be such as to prevent vegetable growth, however rich it may be in the necessary elements.

The following are some of the causes of barrenness in soils:—The excessive preponderance of sand, lime, or even pure clay; too close proximity to the bare rock, the soil only forming a thin layer above; the existence of an impervious clay subsoil not easily drained; defective drainage. Many sterile, retentive clay soils contain all the elements of the food of plants, and only need to be penetrated by the air to make them fertile; break them up thoroughly and let the frost and air act upon them, and vegetation will flourish on them at once.

7. Mechanical Condition of the Soil in Relation to the Growth of Seed.—In a state of nature all plants are propagated from seed. Moisture, warmth, and air are considered essential to the development of all seeds, and most of them require, in addition, concealment from the light.*

* It has been proved that several kinds of seeds will germinate between pieces of ice. Experiments have been made upon wheat, rye, barley, red beet, rape, lucerne, poppy, and many other seeds. Several hundred seeds were employed of each species, and every fourteen days the seeds were taken out of the ice-chest—whose temperature was kept constant between 0° and 1°—and examined in a space whose temperature was under freezing point. In forty-five days a decided beginning of germination was visible in eight different species. In four months it had continued to progress in a minority of these; the rest had stopped. In fourteen species there was no germination. The opinion has been expressed that

To secure these essentials for the well-being of the plant it is necessary that the soil, besides being well stored with available plant-food, should be in such a mechanical condition as to admit of easy access and egress to superfluous water; sufficiently retentive to support the plant firmly in the ground, and to guard against drought; firm enough to protect the roots, and yet so sufficiently yielding as to admit of their passage in search of food, and the subsoil sufficiently favourable to act as an auxiliary with the same ends in view.

8. Power of Soils to hold Manure—how artificially assisted.—A cubic foot of sand weighs about 110 lbs., and a cubic foot of clay about 80 lbs.; yet sands are called light lands and clays are described as heavy lands! The explanation is very simple. The particles of sand are large and coarse compared to the particles of clay, which are an almost impalpable powder, consequently the porosity of clay is far greater than that of sand, *and it contains less solid matter* in proportion to its volume, since the porosity of a soil may be measured by the fineness of its particles.

To the porosity of a soil, then, may be referred its capability of absorbing and retaining moisture,* its degree of capillarity (Lat. *capillus*, hair)—allowing water to *rise* through its interstices—and the action of that attractive force which condenses and retains on its interstitial

---

those seeds which can germinate at a lower temperature than others of the same species, will give plants that require a less amount of heat for their complete development than the others." —"*Nature.*"

* The following table will show the retentive powers of different soils:—100 lbs. of dry soil will begin to drip, if it be a

Quartz-sand	when	it has absorbed	25 lbs.	of water.
Calcareous sand	"	"	29 lbs.	"
Loamy soil	"	"	40 lbs.	"
English chalk	"	"	45 lbs.	"
Clay loam	"	"	50 lbs.	"
Pure clay	"	"	70 lbs.	"

surfaces the fertilizing soluble matters of the soil (5), to await absorption by the roots of plants as they ramify in search of nutriment.

As clays possess this retentive power to such a large extent (see table), it accounts for the excellence of such soils under *good cultivation*. The retentive power of light soils to hold manure may be improved by marling, claying, and judicious manuring, and even the application of lime improves them in this respect, since lime is intermediate between sand and clay in its retentive qualities.

9. Essential Differences in the Cultivation of Light and Heavy Soils.—Light soils, as already observed, are generally of a loose, friable, open, dry character, and for that reason are more easily and less expensively cultivated than any other description of soils. Many consist almost entirely of silicious sand and gravel, with but little alumina and calcareous matters. Such soils are amost absolutely barren, and are often termed *hungry* soils from their tendency to absorb manures without any corresponding benefit to the land. Others contain a larger proportion of the alumina and lime, and are consequently more compact and always more fertile. Sandy soils are capable of improvement, which generally well repays the expense of material and labour.

Clay, marl, chalk, and any substance tending to counteract the loose texture and porous nature of sandy soils may with advantage be applied to them. On the better kind of light soils, turnips and barley do well; hence they have been termed "turnip" and "barley" soils. The usual course pursued in the treatment of such soils is to work it in a way that will render it more compact and solid. The roots are fed off by sheep in the winter, their treading and manuring being a fine preparation for grain.

Shallow ploughing in spring, often when the land is

wet, the use of heavy rollers and the application of well-rotted manure, are precautious adopted to promote consolidation.

The properties of heavy soils containing much clay are distinctly opposed to those of sandy soils, and the system adopted in working them is consequently very dissimilar. They have been termed "wheat and bean soils," because they are most suitable for these crops. When properly cultivated some are turned into highly fertile soils. Their faults arise out of their mechanical structure, not out of their chemical composition. The former may be corrected by draining, the use of bulky manures, and the addition of lime, ashes, &c. Turnips and swedes are unsuitable crops because of the difficulty and expense of securing a sufficiently fine tilth for the proper germination of their small seeds in the spring and early summer, and because both carting off the produce in the autumn and feeding them off in the winter is troublesome and injurious.

The retentive plastic nature of clay lands requires a system of cultivation which shall lighten up a soil already too consolidated, such as autumn ploughing, to realize the full effect of the winter's frost, and the use of long fresh manure, so that its fermentation and decay may open up and divide the tenacious soil.

It is usual on this class of land to grow spring and winter vetches, early white turnips, cabbages, rape, kohl-rabi, and kale as substitutes for swedes and turnips, as the former may be eaten off in the dry months and the ground cleared in time for autumn wheat sowing.

10. Influence of Climate on the Productive Powers of the Soil.—The term climate comprehends all the changes of the atmosphere with respect to temperature and humidity; the phenomena of winds; state of the clouds with respect to their properties of favouring or retarding the solar rays and influencing radiation; the pressure of the air and its electrical condition—all of which,

to some extent, depend on each other, and are more or less intimately connected with agriculture.

The general causes affecting the climate of any locality may be referred to (1) latitude, (2) height above sea level, (3) distance from the sea, (4) proximity to forests, marshes, or large bodies of water, (5) aspect, (6) nature of the soil, (7) situation with respect to protecting ranges of hills and prevailing winds.

On latitude chiefly depends the general character of the climate.

The height of sea level will cause a decrease in temperature in Great Britain to the extent of about 1° Fah. for every 270 feet in altitude. Wheat, in consequence, will not ripen at greater elevations of from 1,000 to 1,200 feet, and other crops suffer in proportion.

Distance from the sea.—Large masses of water maintain a more equable temperature than land. Proximity to the sea consequently gives a more uniform temperature than is conferred on more inland localities.

Forests by their leaves condense vapour, and by precipitating it to the ground help to feed springs; they also give great shelter, especially when situated on high grounds and the slopes and crests of hills.

Marshes and Lakes act unfavourably on climate by augmenting fogs and mists, as well as by noxious emanations inimical both to man and beast.

Aspect, Slope, or *Inclination* has a very material effect on the productive powers of a district by regulating the drainage, and also the amount and intensity of the solar rays which fall upon it. The southern sunny slopes of mountains, pasture lands, gardens, &c., with a favourable aspect, possess well-known advantages over others not so well situated.

Nature of the Soil.—On its texture and composition will depend its power to withstand drought, absorb and retain heat, and generally to modify favourably or otherwise the extremes of climate. Even colour has its influ-

ence, a dark-coloured soil absorbing more heat rays than one of a lighter hue.

Winds have an effect on vegetation according to their direction. In this country those from the north and east are cold and dry, and on the whole unfavourable; while from the south and west the mild, genial influence is favourable to vegetable life. Shelter by ranges of hills from unfavourable winds must consequently be included in any list of modifications of climate. Many of the rotations of crops which are carried out in Great Britain can be distinctly traced to the influence of climate. The system of Scotch husbandry agrees closely with the Welsh and Irish in many particulars where the meteorological phenomena have many points of resemblance.

The comprehensive nature of climatic effects is sometimes greater than that of manure, so that agricultural results will always be dependent on the character of the seasons. The importance of rain or of sun at particular seasons is well known to the practical farmer, whose calculations may be all modified by the absence of rain during the time when plants are forming their leaves, or cool damp weather when the seed is being filled. In experiments by Mr. Lawes it has been found that "the lowest weight of the bushel and the greatest amount of straw correspond with the driest season, and the finest quality of the grain with the hottest summer." The whole bearing of these and other experiments tend to prove that no variation in the quality of manures will enable the farmer to overcome the effect of climate. The most that can be done is to adapt the management of the land to the conditions under which it is placed, endeavouring to take advantage of what is favourable and to avoid what is the reverse.

CHAPTER II.

11. Substances found in Plants.—Plants are organic bodies, deriving their nourishment from the soil, and from the atmosphere through the roots and leaves. The entire body of the plant is a system of cells and tubes destined for the reception and transmission of the sap which rises from the roots towards the upper part. From this passing current each cell extracts the constituents required for its own purposes, and when these are served they are passed on again, or reserved for future needs, or used to increase the solid bulk of the cell itself. The leaves of plants are full of pores through which they drink in carbonic acid and watery vapour. Plants are thus possessed of a vital principle, differing only in form and intensity from that of animals.

All plants may, by burning, be separated into two parts, the Organic, or volatile, which mingles with the air as gas; and the Inorganic, or fixed, which remains as "ash," and which is in reality the mineral matter contained in the plant. The following table shows the substances found in plants:—

Organic.		*Inorganic.*
(Non-nitrogenous)		Silica
C,O,&H only	Starch	Ammonia
	Gum	Potash
	Sugar	Soda
	Cellulose or woody fibre	Lime
		Phosphoric Acid
	Oil	Carbonic Acid
(Nitrogenous)		Sulphuric Acid
C, O, H, & N	Albumen	Magnesia
	Fibrine (gluten)	Oxide of Iron
	Casein (legumin)	Chlorine

Each separate class of plants is known to take up or select merely those mineral matters from the soil which are necessary to elaborate its own structure and to refuse that which is not desirable for its growth. If we take the entire range of our cultivated crops, we find that the whole of the mineral or inorganic matters named in the foregoing table are taken up into their substance. In the words of Professor Tanner, "Alumina appears to act rather as an 'out-of-door' servant, carefully avoiding going into the plant."

12. Source from which they are Derived.—The *mineral matters* are derived entirely from the soil.

The *organic part* of a plant comes partly from the soil and partly from the atmosphere—from the former in the form of its contained carbonic acid and ammonia,* from the latter in the form of carbon, oxygen, hydrogen, and nitrogen. (1.) These four form the elements of the nitrogenous matters, while carbon, oxygen, and hydrogen only enter into the composition of the non-nitrogenous substances. The nitrogenous substances have also received the name of albumenoids from albumen, their leading representative.

13. Exhaustion of the Land.—All plants take from the soil inorganic matters varying both in quantity and variety. It is therefore possible, the soil being the only source of supply, if the same kind of cropping is carried on for a long time without a proper return being made to the land in the form of suitable manure, for the land to become less and less productive and finally "exhausted." The substances which plants require may be still in the land, and that to a very large extent, but they are not *soluble*, and are consequently useless. By allowing the land to rest or remain fallow a sufficient length of time, these insoluble matters will change to the soluble condition

* 6 lbs. of carbon and 16 lbs. of oxygen=22 lbs. of carbonic acid; 14 lbs. of nitrogen and 3 lbs. of hydrogen=17 lbs. of ammonia.

and become "active," thus restoring the exhausted land even without the aid of manure.

The following extracts from tables drawn up by Dr. Lyon Playfair will give an idea of the power of selection exercised by different plants in taking inorganic matters from the soil:—

INORGANIC MATTER REMOVED FROM AN ACRE OF LAND BY AVERAGE CROPS OF THE FOLLOWING KINDS:—

	WHEAT.	BEANS.	TURNIPS	CLOVER.
	Weight in lbs.	Weight in lbs.	Weight in lbs.	Weight in lbs.
Potash	25·70	111·80	201·68	52
Soda	1·87	9·37	39·21	7
Magnesia	7·18	16·27	21·54	35
Lime	10·19	37·21	107·68	111
Phosphoric Acid	19·62	35·83	58·98	20
Sulphuric "	5·90	2·44	78·82	13
Carbonic "	...	...	42·71	...
Silica	102·66	12·56	14·24	10
Peroxide of Iron	1·52	·35	6·29	3
Common Salt	·36	8·05	66·84	8
	175·00	233·88	637·99	259

14. Essential Differences between Good and Poor Land.—By a good soil is meant one having all the conditions necessary for the production of heavy crops. Such a soil will have in itself all the substances which plants require for their growth and maturity, and these various matters will be sufficient, not only for present use, but also ready to furnish future supplies under the ordinary solvent forces.

In this respect its fertility may be measured by the plant constituents present in the least proportion, just as the strength of a chain is measured by that of its weakest link. The physical condition, too, of a fertile soil must be satisfactory with regard to subsoil, drainage,

porosity, tenacity, and other mechanical points—the soil considered as a storehouse, must not only be full, but the key must be forthcoming and the *climate* favourable.

By a poor soil is understood one which is deficient in some of the foregoing advantages, or contains them only to a limited extent.

15. Necessity for Manure.—The term manure in its modern and wider signification includes every substance, whether of vegetable, animal, or mineral origin, which, when applied to the soil, has the effect of increasing its fertility.

That part of a plant which is derived from the air may, in a general sense, be looked upon as unlimited in supply; but the case is different with the mineral matters, which plants take entirely from the soil. The supply of these under continous cropping may be overtaken by the demand, and then fertility decreases.

The condition of the land may, however, be rapidly restored by judicious manuring, which not only supplies the desirable materials, but assists the process of decomposing the dormant mineral matters into those of a soluble form immediately available. Some manures, too, as lime, marl, and farmyard manure, alter and improve the physical character of a soil by opening up and dividing its pores.

16. The Production and Waste of Farmyard Manure.—Farmyard manure consists of the excrements and urine of farm animals, mixed with straw or other litter. It has happily been termed a "general manure," from its capability of restoring the entire loss sustained by the land in cultivation, and so maintaining thoroughly its fertility. When derived from animals liberally fed on roots, hay, corn, and cake, it forms the best known type of a manure for general purposes. In durability, chemi-

cal action, and mechanical effect, it stands unrivalled; but its actual composition and economic value is regulated by the way in which it is produced on the farm, so that analyses can only give a general idea, and will present considerable variations.

Sources of Waste.—If, while accumulating, too much heat is produced by the fermentation which invariably sets in, the ammonia (which is its most valuable part) becomes volatile and flies off.

Too much moisture, on the other hand, will wash away the soluble matters resulting from a proper fermentation, and rich black streams of liquid manure will be observed escaping, which carry with them the organic acids, combined with ammonia in a still more valuable form.

As manure heaps, in a general way, stand in the open air exposed to all the changes of the weather, the heavy washing from the rains form a source of waste which is often overlooked.

17. Conditions regulating the Production, Management, and Application of Farmyard Manure.—*Production.*—The excrement of different kinds of farm stock varies considerably in its properties.

Horse-dung, from its loose texture, readily admits the air, rapidly ferments, and heats quickly, throwing off much ammonia. Its hot nature causes it to be quick in its action, producing a rapid effect on application. Cow-dung is cool and moist and slow to ferment; its action is consequently slower but more lasting than that of horse-dung.

Pig manure is intermediate in its nature between that of the horse and the cow. No manure varies so much in quality, because the food supplied to these animals is so variable. Its value depends entirely on the food—that from fattening animals being far superior to that derived from breeding sows.

TABLE SHOWING THE COMPOSITION OF FARMYARD MANURE.

FRESH COW AND PIG MANURE.				ROTTED—SIX MONTHS IN HEAP.	
	Water		66·17		75·42
* Organic Matters	Soluble...	2·48	28·24	3·71	16·53
	Insoluble	25·76		12·82	
† Inorganic Matters	Soluble...	1·54	5·59	1·47	8·05
	Insoluble	4·05		6·58	
			100·00		100·00

* The organic matters in the fresh manure contained ·780 of ammonia, and in the rotten dung ·735 of ammonia.

† The inorganic substances consisted of silica, lime, potash, phosphate of lime, magnesia, sulphuric acid, carbonic acid, soda, chloride of sodium (common salt), oxide of iron, alumina, &c.

Sheep droppings contain more nitrogen and less water than those of the horse, but its compact nature makes it less ready to ferment. The urine is a very valuable fertilizer, as it contains a large amount of nitrogen, and furnishes ammonia on decomposition. As a general rule, sheep manure forms no part of farmyard manure, or only a small proportion, the animals being mostly fed in the fields.

The quantity of manure made on a farm is limited, to a large extent, to the amount of straw and fodder available. An acre of land growing a ton of straw will produce probably 4 tons of fresh or 2¾ tons of well-rotted dung.* As far as experiments have been made, horses and fattening cattle in stalls will produce one ton a month, and 8 or 10 pigs a similar amount.

The quality of the produce will be influenced by a number of circumstances, of which the following are a summary:—(1) The kind of animal; (2) its age and

* "100 cwt. of fresh farmyard manure are reduced to 80 cwt. if allowed to lie till the straw is half rotten; 100 cwt. of fresh farmyard manure are reduced to 60 cwt. if allowed to ferment till it gets "fat and cheesy;" 100 cwt. of fresh farmyard manure are reduced to 40–50 cwt. if completely decomposed."

condition; (3) the quantity and quality of food supplied; (4) the amount of litter supplied and the material composing it; (5) the management when accumulating; and (6) its treatment during fermentation.

Management.—A certain amount of heat, moisture, and air are essential conditions, without which organic matters cannot enter into fermentation or putrefaction. These conditions exist in the farmyard, hence the fermentation which soon begins in fresh dung.

Nitrogenous substances in the manure heap when decomposed produce ammonia: non-nitrogenous substances produce carbonic acid or some organic acid, such as ulmic or humic acids.

Carbonic acid is formed when the manure gets dry and hot, the organic acids when it is kept cool and moist.

Carbonic acid combines with ammonia and forms carbonate of ammonia, which is higly volatile, and constantly flying off into the air. The organic acids combine with ammonia and form ulmate or humate of ammonia, by which the ammonia is preserved.

Fermentation, if too rapid, can be checked by the judicious use of water, which lowers the temperature and displaces the air. Lightly turning and watering if too dry will hasten fermentation by giving full force to the decomposing influences.

If fermentation be too long continued the whole of the ammonia will be dissipated and lost. It is a common practice with good farmers to make their manure heaps on a foundation of some dry absorbent material, and to cover them with a layer of something similar, in order to absorb the organic acids and fix the ammonia. The following substances are usually applied with more or less success for preventing the loss of ammonia in manure heaps:—

Acids.—Sulphuric, hydrochloric, humic, and ulmic acids.

Tonic Salts.—Green vitriol, gypsum common salt.

Porous Substances.—Charcoal, peat charcoal, peat mould, coal and peat ashes, and earthy matter of every description.

Application of Farmyard Manure.—The condition in which the manure is applied will vary with the time of the year, the class of land, and the crop for which it is intended.

In soils which can be trusted to take care of it, long fresh dung may be carted direct to the field and ploughed in at once during the autumn and early winter. This will apply to some of our clay loams, and loams sufficiently heavy to retain the results of slow decomposition.

In the case of heavy stiff clay the mechanical condition will be improved and the pores opened up and lightened, every straw as it decays acting as a channel to admit the air.

Light soils, on the contrary, should have the manure applied in a short, mellow condition, so that its quick action may be exerted before the porous nature of the land allows the prepared soluble matters to be washed beyond the reach of plant roots. The free character of these soils will not admit of their being rendered more open by the use of manure whose fermentation is only partially complete.

Farmyard manure applied in hot weather, as in May and June, for roots, should be ploughed in at once, so that its "nature" may not be impaired by drying.

The *amount* per acre varies with the crop; and as to the *time* of application, every month in the calendar sees it used, either as a present or preparatory food for one or other of our ordinary farm products.

The following table gives an idea of the amount of farmyard manure supplied in ordinary practice, though this is often supplemented by "artificials" both at the time of planting and also during the period of growth:—

ROOTS.	Tons per acre.
Mangel	20 to 30
Swedes	20 to 30
Potatoes	20 to 30
White Turnips	18 to 20
CORN.	
Beans	12 to 15
Rye	12 to 15
* Wheat	12 to 15
FODDER.	
Rye	12 to 15
Vetches	12 to 15
Clover	12 to 15
Grasses	12 to 15
Cabbages	20 to 30

* The farm manure for most of the corn crops would be in the land with the preceding crop. See Chapter on Rotations.

18. Variations in Quality and Consequent Results.—In the preceding paragraph is a list of points which affect the quality of manure made in the farmyard.

(1.) *The Kind of Animal.*—The droppings from horses, cattle, sheep, and pigs have each their characteristics, both physically and chemically. (17).

(2.) *Age and Condition.*—Young animals are fed with a view to increase their bone and muscle, and their food is more thoroughly consumed than full-grown beasts, which have only to keep up their condition. The manure from these will always be less rich than those of full grown animals fed with the same kind of food. The urine of a calf fed on milk contained, on analysis, 1 lb. of solid matter and merely a trace of nitrogen in 1000 lbs.; whereas the same quantity from a full-grown cow contained 80 lbs. of solid matter and 8 lbs. of nitrogen.

The manure from stock in poor condition is less rich than that from fattening animals, the former absorbing much more nutriment from the food than do

the latter. Cows in calf and milch cows are, in a manner, similar to young growing animals, the fœtus and the milk taking up the phosphates, salts, and nitrogen.

(3.) *Quantity and Quality of Food Supplied.*—Liberal supplies of food will produce liberal supplies of manure of good quality. If an animal has no more than it requires to keep up its strength for working, or its milking qualities, the food will be so thoroughly used up by the system as to leave very little manure, and that of inferior quality. The quality will, to a still larger extent, depend on the nature of the food supplied.

Foods rich in nitrogenous matters will result in far better manure than those comparatively poor in proteine compounds, such as straw, turnips, potatoes, &c.

A large proportion of water will cause the manure to be very much diluted. Green foods for this reason cannot furnish such rich manure as the same quantity of dry food.

(4.) *Amount of Litter and the Material Composing it.*—The composition of wheat, barley, oats, and bean straw not being the same, the quality of the manure will be thereby affected according to which of these is used for litter. The two latter contain more fertilizing substances than that of the straw of wheat or barley. Too much litter will impoverish the manure, but it should be sufficient to absorb the urine, which contains valuable soluble salts and more nitrogen than the solid excrement.

(5.) *Management during Accumulation.*—In addition to sustaining a proper degree of fermentation, the various supplies from the stable, the cattle sheds, the piggeries, the poultry house, &c., should be equally distributed throughout the heap. (129.) An excellent plan is to allow the drainings to run into a tank: they are thus utilised by being again poured over the heap, or taken to the fields in a liquid condition. These drainings are

often lost through want of proper precautions in securing them.*

(6.) *Treatment during Fermentation.*—Many persons allow the dung to accumulate under fattening animals, adding fresh litter as required, and theoretically the advantages of this so-called box dung must be obvious. The urine is better absorbed and retained; the fermentation is regular and slow from the compact nature of the manure; the ill effects of sun, heavy rains, and drying winds are prevented, and by the larger amount of humus formed, the ammonia is fixed to a greater extent than in the ordinary open-air conditions of the manure heap.

The following analyses of box manure and farmyard manure will show the results of the two systems of management:—

Box Manure.		Farmyard Manure.
Water	71·04 per cent.	71·00 per cent.
Ammonia	2·37 " "	1·70 " "
Soluble organic matters	6·42 "	1·82 " "
Soluble inorganic " consisting of phosphoric acid, potash, and soda	4·18 "	2·78 " "
N.B.—Also a trace of lime and a considerable amount of silica not determined.		

The following results are from manure stored up in *covered sheds* and farmyard manure made under the ordinary conditions. Lord Kinnaird, a Scotch landowner and farmer, tried the following experiments:—Four acres of good soil were measured, two of them were manured with ordinary farmyard manure and two with an equal quantity of manure from a *covered shed.*

* Analysis has shown these drainings to contain from 1 to 1½ oz. of solid fertilizing matter to every gallon of liquid.

The whole was planted with *potatoes*. The product of each acre was as follows :—

Results from Farmyard Manure.	Results from Covered Manure.
1st acre 272 bushels	1st acre 442 bushels
2nd acre 292 „	2nd acre 471 „
Total 564 „	913 „

The next year the land was sown with wheat, when the crop was as follows :—

Results from Farmyard Manure.	Results from Covered Manure.
1st acre 41 bushels.	1st acre 55 bushels (61 lbs. per bushel.
2nd acre 42 „	2nd acre 58 bushels (61 lbs. per bushel.)
Total 83 „	113 bushels.

The straw also yielded one-third more upon the land fertilized with the covered manure than upon that to which the ordinary manure was applied.

19. Under what Conditions is Green Manuring Desirable?—By green manuring is understood the ploughing in of green crops, such as mustard, vetches, green rye, rape, &c., and even common white turnips.

This system of manuring returns to the land the elaborated juices and organic matter which the green crop contains. The effect of the decay of the vegetable tissues is favourable to the physical condition of the soil, and the various elements derived from the atmosphere (12) are returned again to the land.

The plan may be adopted on a piece of foul land, when the weeds and insects may be completely eradicated and the soil cleaned and improved in condition by "ploughing in" two or three (if necessary) consecutive crops of green forage. White mustard, from its rapid growth, has been found available in this way.

When, however, the green crop would prove of greater value as food for stock, the practice would scarcely be adopted or recommended.

CHAPTER III.

20. The Use of Artificial Manures: How Manufactured, and the Reasons for their Employment.—If all the food grown on a farm were consumed by the stock, and the manure returned to the land, the soil would receive as much as, or more than, it lost, and in many cases increased fertility would result. But practically certain exhausting crops, as hay, corn, potatoes, &c., are often sold off, and beef, milk, mutton, and wool almost invariably so.

The supply of farmyard manure being limited (17), the annual production is unable to replace all the materials carried from the soil by the crops grown upon it. To supply this tax on the land and to supplement the products of the farmyard, &c., "artificials" are used. These *portable manures* have had a revolutionary effect on modern cultivation—poor soils have become improved, good land brought to a state of the highest perfection, heavier crops, and of better quality, produced, and new crops introduced into the usual rotations.

Artificial manures are those which are specially manufactured for a definite purpose; but under this term, certain substances may be included, which, strictly speaking, are natural manures (43), such as lime in its various forms, nitrates of soda, and even guano as originally discovered on its native rock. Waste products will be treated of hereafter. (37.)

The principal artificial manures in common use are:—

I. *Nitrogenous or Forcing Manures*—

1. Substances containing ammonia, such as ammoniacal salts, Peruvian guano, ammoniacal liquor from gas works, and soot.

2. Substances containing nitric acid, such as saltpetre, Chili saltpetre, and nitre earth.

II. *Manures which contain potash* (strongly forcing) which include potash, nitre, and some sort of marl.

III. *Manures containing much soda.*—Chloride of sodium or common salt, sea salt, hide salt, nitrate of soda, and certain minerals.

IV. *Phosphatic Manures.*—Bone ash, animal charcoal, phosphate coprolites, apatite (mineral superphosphate), Saldanha Bay guano, and all other kinds of guano, and bones.

V. *Manures containing sulphuric acids.*—Green vitriol and sulphuric acid.

VI. *Calcareous manures*, as burnt lime, chalk, marl, and gypsum.

Another division might be made out of manures containing much humus, and consequently termed carbonaceous manures, also of those containing much silica, as sand, ashes of coal, and peat, &c.; but as these would hardly come under the head of artificials in the ordinary acceptation of the word, they need not be included in the list.

Ammonia receives its name from the Temple of Ammon in Libya, which was visited by the camels from whose dung the muriate of ammonia was first produced. Ammonia is highly volatile alkali, obtained from the decomposition of animal and vegetable matters containing nitrogen. (Footnote to 12.)

Ammonia has a variety, of compounds, of which the following are the most important :—

Acetate of Ammonia, produced by the union of acetic acid with ammonia as its base.

Carbonate of Ammonia, consisting of carbonic acid and ammonia.

Muriate of Ammonia.—A combination of muriatic acid and ammonia.

Nitrate of Ammonia which is nitric acid and ammonia.

Sulphate of Ammonia, consisting of sulphuric acid combined with ammonia.

Ammonia, nitric acid, and the other nitrogenous [ammoniacal] compounds when applied to plants are taken up in a very dilute state by their roots and help to form the nitrogenous part of their substance, viz., albumen, gluten, and caseine (11).

Sulphate of Ammonia is made from the waste liquor of gas works by treating it with sulphuric acid in sufficient quantities to combine with the ammonia, after which the sulphate of ammonia is precipitated in the form of crystals more or less discoloured by impurities.

Soot contains lime and sulphate of ammonia, and to its latter property its value as a manure is principally due. The value of sulphate of ammonia depends on the percentage of ammonia which it contains. It is combined with other fertilizers in the manufacture of artificial manures, and as a nitrogenous manure exerts an influence as important as that of Peruvian guano.

Potash is a saline matter or alkaline salt obtained by boiling the ashes of wood with water and afterwards boiling the liquid to dryness. Large quantities are used in soap and bleaching works.

Being an important element in all fertile soils, and largely taken up by certain crops, such as wheat, beans, turnips, clover, &c., it is a matter of necessity that potash should be present in the soil in sufficient quantities.

It enters largely into the composition of potatoes, hops,

and vetches. Dr. Playfair estimates an acre of wheat to extract from the soil upwards of 25 lbs. in the corn and straw; an acre of clover 52 lbs.; of beans 111 lbs.; and of turnips, including their tops, no less than 200 lbs.

Formerly potash commanded a very high price, but in 1859 an abundant source of crude potash salts was discovered in Strassfurt, in Prussia, which has so much reduced its commercial value that it can now be bought at £4 per ton.

Some miners engaged by the Ducal Government, after sinking to a depth of 1,150 feet came upon an inexhaustible bed of rock salt, extremely rich in potash salts. From this supply the manure known as Kainite is manufactured, and largely sold as a source of potash for manurial purposes. Kainite usually contains potash salts as a *sulphate* to the extent of about 25 per cent., but has not in its manurial action realized general expectations.

Nitrates in chemistry are salts formed of nitric acid (of which nitrogen is the foundation*) and a base, and the formation of the compounds is continually going on in nature, more especially in warm countries and in particular localities.

The *nitrate* of potash is found in great quantities in the soil in some parts of India, and nitrate of soda in Peru. In these cases the salts are obtained by lixiviating (washing) the soil and crystallizing the clear solution by evaporation.

Nitrate of potash is a very powerful manure, but commands a high price, being used in the manufacture of gunpowder.

Soda is obtained from common salt which is composed of chlorine and sodium. The chief source of supply is from salt mines and sea water, though sea salt is unusually disposed to become moist. Soda being found in all

* 14 lbs of nitrogen and 40 lbs of oxygen form 54 lbs of nitric acid.

good soils and also taken up by plants, its use will depend on the proportion the demand bears to the supply. Lands situated near the sea are supplied by the sea breezes, considerable quantities being carried inland in this way as far even as forty miles.

Nitrate of Soda occurs in Peru in large beds, sometimes 7 or 8 feet thick. Being in one of the few "rainless districts" of the earth, this and the guano found there are preserved from solution by the extremely arid nature of the country. Nitrate of soda is extremely rapid in its action and very soluble, and should in consequence be applied at the seasons when active vegetation commences. Its effects resemble that of all nitrogenous manures, and are speedily apparent in the darker foliage and general luxuriance of growth noticed shortly after its application. It is largely employed for manufacturing purposes, and this helps to keep up the price, which ranges from £13 to £16 per ton. To the cereals, Italian rye grass, pastures and meadow land, nitrate is usually applied in small quantites and at intervals as a top-dressing. Common salt or superphosphate of lime applied at the same time is attended with considerable advantage to the crop. Nitrate of soda should be kept from contact with seed when used for manure for roots, as it is apt to injure the vitality of the seeds. From 1 to 1½ cwts. per acre is abundantly sufficient and in Norfolk has been found to increase the corn crop from 7 to 8 bushels per acre.

A phosphate is a salt formed from phosphoric acid and a base. By far the most important form of phosphatic manure is that of phosphate of lime. Bone phosphate is derived from dissolved bones (table to 22), but is now most difficult to obtain in its pure and unsophisticated form.

Mineral phosphate or apatite, a white earthy substance, is now commonly used as a source of phosphoric acid, and a cheap and efficient substitute for bone. Our supplies

are derived from Welsh phosphatic limestone, French, German, and American phosphates, and from Canadian, Spanish, and Portuguese phosphorities (native phosphate of lime). Phosphatic deposits are also found in some of the islands in the West Indian and Caribbean Seas —Sombrero, Navassa, Aruba and St Martin, and known as Sombrero rock phosphate and Navassa West (so called) guano.

Bone phosphate is made by dissolving bones in sulphuric acid. A large number of minerals containing insoluble phosphates are similarly treated, and become changed to soluble substances known as mineral superphosphates.

A common source of supply is afforded in what are known as "coprolites," which are supposed to be the fossil dung of extinct animals—fishes and reptiles—occurring abundantly in the lias and coal formations.

"Coprolite diggings," are worked in Cambridge, Beds, Bucks, Norfolk and Suffolk. Russia and France also export mineral nodules of a similar kind for the same purpose. Various fossils are now practically included under the name of coprolites, as their composition embraces several substances valuable to the manufacturer. About one-half or one-third of their weight of sulphuric acid, which is very powerful, is necessary in the manufacture of mineral superphosphates from these various phosphatic matters, and the quality of the manure will vary according to the source from which they are derived, and the amount of acid used in dissolving the crude material.

"Reduced phosphates" are those in which some of the matters rendered soluble by the action of the acid have gone back again to their original insoluble or difficultly soluble condition. The agricultural value of the phosphate so precipitated is but little, if at all inferior to soluble phosphate itself, and is probably of a similar character to that which the soluble phosphate assumes

after remaining a short time in the soil. Dr. Morfit remarks :—"If there be any carbonate of lime, alumina, oxide of iron, or powdered mineral phosphates mixed with the ordinary soluble phosphate, part of it is apt to become insoluble, even in the bags." Such reduced phosphates are slower but more lasting in their action, and will be again brought to their original soluble condition by time and favourable circumstances.

Guanos vary in their properties to a very important extent, some being valuable from their high percentage of ammonia, and others, such as Saldanha Bay guano, containing as much as 50 or 60 per cent. of phosphate of lime and only 4 or 5 per cent. of ammonia. The various kinds should be used according to their composition as sources of either phosphates or ammonia, or as combinations of both.

Manures containing sulphuric acid are used also as fixers of ammonia, such as gypsum, sulphuric acid itself, and green vitriol.

Calcareous Manures—Chalk, marl, and the various forms of lime are treated of in Chapter IV.

21. Conditions regulating the use of Artificial Manures.—The particular *kind* of artificial manure to be used on any piece of land, the *quantity* used, and its *chemical condition* as to solubility, &c., will be regulated more or less by the following points :—

1. The amount and quality of farm manure available.
2. Its general state of fertility, whether requiring manure in bulk or only a stimulant.
3. Its situation as to distance and accessibility with respect to hauling bulky manures.
4. The position it occupies in the rotation observed on the farm.
5. The physical condition of the land, whether "heavy" or "light."

6. The kind of crop to be taken, and the use to be made of it, whether to be carted off, fed off, or used as a green manure.
7. The condition of the land with respect to freedom from weeds, couch grass, &c., and the time of the year in which the "artificials" are to be applied.

22. Bones as a Manure, and how they are most Economically Employed.—The first step towards the use of artificial manure was the use of bones—a practice which dates from the commencement of the present century.

The composition of bone varies according to the age and character of the animal, generally containing less earthy matter when the animal is young, and increasing in quantity as it grows older. In adult animals the earthy matter does not vary to any large extent, being about 67 per cent. in thoroughly dry bone, the other 33 per cent. being the organic part. The mineral constituents present phosphorus, lime, magnesia, and soda; the organic portion yields sulphur, carbonic acid, and ammonia.

The organic and mineral matters in bones are only slightly soluble, so that their action extends over a long period.

The following table gives the composition of *raw bone*:—

Phosphate of lime	48·95
Lime	2·57
Water, sulphuric acid, Magnesia, and silica	9·35
Organic matter (gelatine, &c.)	39·13
	100·00

Bones were first used as "half-inch bone;" then as "bone dust." They were soon found to be more soluble by being *fermented*, which was done by moistening them with water and covering them up with fine earth or sawdust. These improvements were in constant use till

1840, when Professor Liebig introduced the use of sulphuric acid for rendering bones *immediately soluble* in water, and by this plan he practically succeeded in doing at once more than the carbonic acid of the air and soil accomplished in a year, and the manure thus rendered soluble soon came into use under the name of bone phosphate.

Boiled bones, deprived of their organic part, are usually used, also bone ash and animal charcoal, as these contain from 70 to 80 per cent. of phosphates.

Phosphate of lime exists in three forms, usually known as tricalcic, bicalcic, and monocalcic, and as in each case there are three equivalents of base, phosphate of lime is often spoken of as a tribasic phosphate.

The phosphate of bone is the tricalcic phosphate, and this, when treated with sulphuric acid, becomes a superphosphate of lime, *i.e.*, the phosphoric acid before combined with three equivalents of lime is found to be concentrated upon *one* equivalent of lime, which thus becomes *supercharged* with phosphoric acid or *superphosphated.*

From this it will be evident that superphosphates contain sometimes not more than a quarter of their weight of monocalcic or active phosphate. The action of bones thus treated is greatly accelerated; and so much is this the case that it is occasionally found to produce vegetation of an unhealthy character, through being, as it were, over-manufactured. With this exception, in whatever form bone may be used, whether boiled, burnt, or raw, rough, crushed and sifted to sizes, decomposed by acids in compost, or by itself fermented with water or liquid manure, or partially decomposed with lime, ashes, earth or animal substances, it has the capacity to furnish a large proportion of the organic part of our farm crops, improving the physical condition of the soil and imparting a perceptibly healthy character to vegetation by its action.

Of all these various forms the half-inch bones are slowest and most durable. These are best employed on light loams and well drained lands, where they form a permanent improvement. In the growth of turnips, and on pastures and sheep lands, deprived of the phosphoric acid by the production of meat, wool, and milk, they have been applied with great benefit and profit.

By its application the immense breadths of inferior uplands, the numerous tracts of calcareous and sandy heaths, desolate wastes, and gorse lands have been transformed into noble turnip fields, and profitable districts, thus abundantly testifying to its ability as a fertilizer and to its specific results. Its value is further augmented by its portability and certainty of action, well kept in hand by the varying amount of solubility possible in its manufacture.

CHAPTER IV.

23. Lime, Marl, Chalk, as Manures.—*Lime* is added to the soil in combination with phosphoric acid and sulphuric acid, in the form of phosphates and sulphate of lime, but these are used principally for the acids they contain.

As a manure in itself, however, the carbonate of lime is the form in which it is usually applied to the land. In a natural state lime is found in the form of chalk, marl, limestone, and shell sand.

From limestone *quick or caustic* lime is produced by burning, and slaked or slaked lime, when this is reduced

to powder by the application of water. The burning causes the water and carbonic acid to fly off, leaving it in a highly porous state and with a metallic ring. The slaking causes the water to be re-absorbed, whereby a new product, *hydrate of lime*, is formed, and this, when the carbonic acid of the air enters into combination with it, is changed into carbonate of lime and loses it caustic character.

Marl is a mixture of lime (in the form of carbonate), clay, and siliceous substances, all of which act beneficially when applied to the land.

The composition of marls is very varied, the lime ranging from 8 to 80 or 90 per cent. of its substance.

They have been classified, according to their composition, as "*true marls*," containing much lime, and "*clay marls*," in which clay predominates. The former are used as a substitute for lime on heavy soils, and the latter generally applied to light lands or lands deficient in soluble alkaline salts, where its potash and other salts supply the defects. Their physical effect is exercised in altering the condition of soils to which they are applied, and their chemical effect in adding direct nourishment and producing larger crops.

Chalk may be described as a soft and very pure variety of limestone; it is a carbonate of lime, and when examined under the microscope is seen to be mainly composed of minute shells, but its composition varies very much in different localities. As a manure, chalk is a great improver of both clay and sandy soils, so that the plastic clay which overlies it, and the green sand beneath it, are precisely the soils calculated to derive the greatest benefit from its application both physically and chemically. It is usually applied at the rate of 20 tons to the acre, and its effects are considered to be of greater duration than that of lime.

24. Action of Lime as a Fertilizer.—The action of lime may be thus summarised—

1. In its caustic condition as a hydrate of lime:—
   (a) Its rapidity acts on the organic matter in the soil by promoting decompositions which convert nitrogen into available ammonia.
   (b) It neutralizes and renders harmless the organic acids existing in what is known as "sour" land, a process which sweetens and improves the quality of the herbage.
   (c) It favours the formation of nitrate of potash or saltpetre in the soil.
   (d) It decomposes the silicates of the inorganic part of the soil, setting free their alkalies (potash and soda), and thus changes dormant ingredients to others of an active character.
   (e) It promotes the formation of the double silicates.
2. In its milder form as a carbonate of lime:—
   (a) It contributes a supply of lime as plant food.
   (b) It neutralizes organic acids.
   (c) It exerts a powerful mechanical effect on *sandy* soils by imparting a certain amount of tenacity; on *heavy* soils, by opening up and dividing their pores; and on *peat* soils by breaking down their vegetable fibrous tissues.

25. Control of its Causticity according to required Results.—Although lime, when its caustic properties are gone, loses much of its energy, it has still—as a carbonate of lime—the power of assisting the fertility of the soil to a very important extent. It should, however, be a matter of care and attention to apply the lime in a caustic state, so that the land may have the full benefit of its action.

To secure this the lime should be slaked in heaps, and then closely covered with a coating of earth, which should remain till it is spread on the land, already ploughed, and then harrowed in *at once*, before the carbonic acid of the air combines with it and robs it of part of its power. Harrowing is preferable to ploughing it in, as its known tendency to sink in the soil will make it dis-

appear fast enough. The application of lime will develope the powers of the soil, by preparing its organic constituents for the crop; but this process continued will soon induce exhaustion of the land unless accompanied by liberal supplies of farmyard manure. These should not be applied *at one and the same time;* the safe plan is to plough the manure in first, and use the lime after, so that the liberated products may be secured by the soil instead of being dissipated and lost.

In compost heaps lime forms an important and necessary element. These may be described as accumulations of fertilizing materials mixed with about 15 or 20 per cent. of lime. The combined influence of these ingredients, if the mixture be judiciously blended, should exceed the sum of their fertilizing effects if used separately, both by increasing the chemical properties of the elements, and also their physical properties in the mass.

The usual constituents are such as are found on all farms in more or less abundance—hedge-clippings, roots, and fallen leaves; weeds, couch grass, sods, and turf; hedge parings, ditch scourings, and road scrapings; together with blood, and other animal remains, mixed with whatever comes to hand in the way of ashes, soot, soap suds, and household waste of all descriptions, all of which are best preserved, prepared, and most evenly applied in the form of compost.

Reference has been made to the action of caustic lime in forming nitrate of potash in the soil.

As far back as 1775 a prize was offered by the French Government for the best method of producing saltpetre in that country for the purpose of making gunpowder. This prize was won the next year by a Mons. Thouvenel. The plan he adopted was to make a compost of earth and nitrogenous matters, either sheep manure or decaying animal or vegetable remains. After a time marl or chalk was introduced, and the resulting decomposition produced nitrate of potash, which was

afterwards washed out by water and secured by evaporation. The compost was made in small heaps and protected from the rain. Caustic lime, when used instead of marl or chalk, separated part of the potash in the soil itself.

From this it is perfectly fair to assume that farmyard manure in the soil, under the action of caustic lime—by securing the necessary conditions, nitrogenous matters, earth and lime—will produce nitrate of potash, similar in a degree to these specially prepared "nitre beds."

Double Silicates.—Silica or siliceous acid forms a very important item in the composition of soils, especially in those of clay.

It has already been noticed (8) as associated with alumina, as silicate of alumina, and forming with lime, soda, potash, and ammonia the valuable compounds known as the double silicates.

The presence of lime appears to be absolutely necessary to *commence* this chemical change. It replaces in the silicate of alumina part of its alumina and forms the first and least valuable of the double silicates, viz., silicate of alumina and *lime.*

This step once complete, however, the formation of the other and more valuable double silicates follow in due course—soda will replace the lime, potash will replace the soda, and the presence of ammonia will cause even the potash to lose its position, and, by taking its place, form the most valuable of all the double silicates, viz., silicate of alumina and ammonia. The chief difficulty appears to consist in the establishment of the first step in the soil, and as this is doubtless due to the energy of caustic lime, its supreme importance will be admitted.

When slaked with water containing salt, the chemical action of caustic lime on silicate of alumina appears to be considerably augmented with respect to the formation of these double silicates.

26. Action of the several Phosphates of Lime as Fertilisers.—Phosphates are combinations of phosphoric acid with a base, such as lime, potash, soda, magnesia, &c. Of these, phosphate of lime is by far the most important. Phosphorus itself occurs in a state of organic combination in blood, flesh, milk, and brains, and also in other animal matters; in bones, phosphate of lime forms very nearly one-half of their substance.

Phosphate of lime also enters largely into the composition of all our cultivated crops, especially in the cereals. Such a universal requirement, as might be expected, forms a part, but only a small part,* of all fertile soils, but continuous calls upon it, both for animal and vegetable supplies, make its application in the form of manure a matter of necessity under high-class cultivation, and hence the great esteem in which the phosphates are held and the immense advantages arising from their use.

27. Conditions rendering their use so generally necessary.—The fertility of the soil depends on the presence of *all* the substances required by plants, and the measure of its fertility depends on that particular ingredient present in the least proportion. As, therefore, phosphates are in such general demand to build up both vegetable and animal structures, and as in the former the cereals are to such a large extent sold off the farm, and in the case of the latter almost invariably so, the fact is patent that the abstracted materials must be artificially and systematically returned if fertility is to be permanent. Twenty-five or thirty gallons of milk will contain about 1 lb. of phosphate of lime, and the demands on the land for this substance will be about 80 lbs. per annum for each cow on the farm. No wonder then, that, the use of phosphates, has become a settled and highly remunerative practice.

---

* In our richest soils phosphoric acid barely forms 8 oz. out of every 100 lbs. of soil

28. Control of their Soluble Conditions.—Phosphates are manufactured with various degrees of solubility. As before mentioned, the phosphate of lime contained in bone in its natural state is known as the tricalcic, that is, it contains three equivalents of lime or base to one of phosphoric acid.

If applied to the land in this condition the carbonic acid of the rain water, and also that produced in the soil, will bring about a change in its composition by replacing one equivalent of lime, and this *bicalcic phosphate* thus formed being slowly soluble in water becomes taken up into the circulation of plants.

In the early stages of the use of bones, farmers used to reduce them to a fine condition by grinding, and this "bone dust" as it was called, was very rapid in its action.

The next step in advance was to "ferment" them. Half-inch bones were arranged in a heap, moistened with water and covered up with earth or sawdust. In a few weeks the heating or fermentation they had undergone had softened them, and they were sooner broken down and rendered capable of supplying their store of phosphate of lime to the plant. Another improvement was soon discovered, for in 1840, Professor Liebig made known to the agricultural world that the use of sulphuric acid —which is very powerful—would render them soluble *at once*, and from that time the solubility of bone was secured *before* putting it into the land, and the phosphoric acid being precipitated into *one* equivalent of lime, it became changed to a *monocalcic phosphate* and known as *super*-phosphate.

The use of this manure in actua practice has shown that it is in fact *too soluble*, producing sometimes vegetation of an unhealthy character. The admixture of lime, if it is already deficient in the soil, would often remedy this injurious action by bringing it back to the *bicalcic* or more slowly soluble condition. Finely

powdered bone is sometimes used for the same purpose, and greatly adds to the "staying" properties of the manure, so also will the alkaline properties contained in ashes.

29. How to Avoid their Waste in the Soil.— (a) By applying them in such a state of solubility that they shall not be washed out of the soil *before* made use of by vegetaion. This may be effected by "mixing," so that soluble and difficultly soluble portions may be applied for present and future use.

(b) By applying them where they are wanted, *i.e.*, where the soil is deficient in this respect.

(c) By applying them only to such soils as can utilise them and prevent them from being washed away by rains or suffer such changes as may render them ineffective before the plants can take them up.

30. On what Soils most economically used.—Phosphates may be used with advantage on light loams, well-drained lands, hill pastures, pastures for dairy purposes, and grass lands where young stock is reared.

Bones are sometimes powdered and mixed with water for application by means of a water drill. This is found to be beneficial on slowly-acting stiff soils, but where the soil is light, open, gravelly, and quick in action, phosphates are better applied in the usual dry condition.

31. Their Action on Seeds and young Plants.— All seeds contain a certain amount of starch, gluten, and oil, and all plants depend on the seed for their nourishment in the earlier stages of their growth.

During the process of germination the gluten is brought into solution by oxygen, and this forms diastase, which changes the starch of the seed into dextrine or grape sugar and finally into cellulose. Cellulose forms organised cells, and these give rise to the first little shoot.

Phosphatic manures are supposed to facilitate the movements of albumen in the plant; to assist in the

elaboration of the oily parts, and also in the changes alluded to above by stimulating the processes; and hence phosphates have been termed grain or seed-forcing manures.

It must, however, be confessed that the precise mode of action is as yet imperfectly known, as the subject has not yet received thorough investigation.

32. Special Action of Nitrates and Ammoniacal Manures upon Corn Crops, Roots, and Grass.—Ammonia, nitric acid, and other nitrogenous compounds, when applied to plants, are taken up in a very dilute state by their roots, and help to form the nitrogenous part of their substance, viz., albumen, gluten, and casein. (11.)

These manures also have a rapid and stimulating effect, which is manifested in a very few days after their application by the dark colour and healthy look of the crops.

33. Means of Controlling the Soluble Condition of Ammoniacal Manures.—This might be done by taking advantage of the absorbing properties of peat, loam, &c., in retaining ammoniacal compounds, and also by mixing ammoniacal manures with other substances.

34. Conditions under which Nitrates can and cannot be substituted for Ammoniacal Manures.—According to Professor Church, whom the author has consulted, "these points are not yet wholly worked out, but nitrates can only be used when there is growing vegetation to use them, that is, in the spring. If used in the autumn or winter they would be washed out of the soil, while ammoniacal salts would be retained in part."

35. The Special Action of Salt when used alone or in combination with other Manures.—Salt supplies the necessary element of soda to the soil, and has long been employed as a manure.

It is specially useful for mangel-wurzel and wheat, while beans, onions, and cabbages do well with liberal

supplies. 5 cwts. per acre is a heavy dressing, especially of sea salt, which is often of service on warm, dry soils, and on the herbage of coarse pasture lands, but cold clays derive the least benefit from its application. It may be applied to inland soils and on those sheltered by hills and high lands from the winds that pass over the sea.

Salt is sometimes mixed with farmyard and compost manure, and when used with the water in slaking quick lime for the land, is said to favour the formation of the double silicates. Its property of checking plant growth is its most important influence. It shortens and strengthens the straw of corn, when used on crops which are too luxuriant, and by thus giving the plant time to elaborate and bring up the necessary mineral supplies, the crop of corn is increased. Combined with nitrate of soda, it neutralizes its rapid action and secures its more uniform distribution by increasing the bulk, and better results are produced. Hide salt, or the salt used in preserving hides during the voyage from South America and other parts, possesses very valuable animal impurities, which increase its powers as a fertilizing agent.

36. Manufacturing Wastes valuable as Manure.— These are exceedingly numerous, and some of them very powerful in effect, being concentrated in character, and furnishing valuable and constant supplies of ammonia during decomposition. Manufacturing wastes may conveniently be divided into animal, vegetable, and mineral substances, of which the former are most valuable, the vegetable matters most numerous and abundant, and the latter of least utility.

(*1.*) *Animal Waste Matters.—Refuse from Slaughter-houses.*—Blood and flesh contain the elements of ammonia, as well as many valuable mineral ingredients necessary to fertility. They are also dried and used in a powdered state mixed with other manures, as in the "nitro-phosphate," or blood manure.

Wastes from Sugar Refineries.—These consist of animal charcoal (bones burnt in iron retorts), blood, and some lime. They are used (1) to remove the colour from raw sugar; (2) to clarify the liquor, and (3) to destroy the acidity in the sugar.

Woollen Waste.—Wool itself is very nearly all animal matter, having only two per cent. of ash. "Shoddy" is the short ends and refuse of the wool obtained during the process of manufacture. "Croppings" are the ends of the wool cut off the surface of the cloth. "Sweepings" are the short dust separated in the process of manufacture and mixed with other accidental matters. "Singeing dust" is made by stuff goods being passed quickly over a red-hot cylinder in order to burn off all superfluous filaments.

Woollen rags, in effect, are similar to woollen waste, except that it is apt to be somewhat slower in its action.

Horn shavings, hair and skin fragments, owe their value to the nitrogen they contain, but hair and wool also contain 5 per cent. of sulphur. They impart permanent fertility, but as they are so slow in decomposition they should be applied at least six months before the sowing of the crop they are intended to benefit.

Fish refuse in some localities is so abundant as to be had for little or no cost, and should then be secured as a manure. Its action is almost identical with that of flesh, with the important addition of phosphoric acid. Fish bones, too, are rich in potash. Guano itself is merely digested fish—the dung of fish-feeding birds.

Attempts have been made to convert fish offal into a dry substance for manure called "fish-guano," but with only partial success.

(*2.*) *Vegetable Waste Matters.*—*Soap waste* comprises a variety of elements, some of which are of animal origin as well—fat and animal matters being in solution in the

waste liquid together with potashes, lime, and other saline ingredients of plants.

Tanners' bark, though generally neglected as a manure, being the product of vegetation, will undoubtedly form a plant food. It is best in the form of compost with lime and earth, or with liquid or solid farmyard manure. Being principally composed of carbonate of lime and silica, substances occurring almost everywhere, it is but little valued.

Sawdust is useful to form a vehicle for taking up liquids, but in itself its composition possesses but little value as a manure. Mixed with dilute sulphuric acid it is one of the best materials for fixing ammonia in stables.

Malt refuse consists of the detached shoots of the germinated barley grain which are separated in the process of malting. Analysis shows it to be particularly rich in nitrogen, while its ash contains more than 60 per cent. of phosphoric acid and alkalies. It is generally applied as a top-dressing, and is particularly effective on grass land.

Oil-cake is sometimes used as a manure, and rape cake in particular, which is not much liked by cattle. It contains 4 or 5 per cent. of nitrogen, and is rich in phosphoric acid. When in a fine condition it readily enters into putrefaction—much more so than bone dust—producing an almost immediate effect.

Sea-weed in compost is in general use where it is easily obtained. It is the general fertilizer for potatoes in the Hebrides, and is also used in places along the coast of England, Wales, and Scotland.

It is peculiarly rich in potash, soda, lime, &c., and is used in its green state as a top dressing, being quick in decomposition. Two and a half tons are considered as equal to one load of farm manure.

Ashes, as the inorganic part of vegetables, are of use as fertilizers by affording these constituents to future crops; still it is not advisable to consume the organic

part of any plant to supply others with inorganic matters. Without incurring this waste we have ashes as the remains of peat, coal, wood, and sea-weed.

(3.) *Mineral Waste Matter.*—*Gas waste* consists of *ammoniacal liquor* which furnishes sulphate and muriate of ammonia; *gas lime* which on exposure to the air becomes sulphate of lime, or gypsum, but should never be applied in its fresh state on account of its sulphur; *and gas tar*, which *might* furnish carbonic acid, but is now put to a much more valuable purpose in the manufacture of perfumes, &c., and various dyes.

Redonda Island Phosphate of Alumina yields impure phosphoric acid, which is manufactured into artificial manures. It is a by-product in the manufacture of alum. This and other crude alumina phosphates are used, too, in clarifying or precipitating town sewage.

37. Adulteration of Manure.—Artificial manures are perhaps more liable to adulteration than any other article. So much is this the case that the services of the chemist are in general request to protect the farmer from the frauds of dishonest dealers and manufacturers of manures. The practice of selling "special" and "prepared" manures gives great latitude to the unprincipled dealer, and creates a prejudice against what may be, and indeed often is, a genuine article offered at a fair price.

Guano is adulterated by mixing with yellow powdered clay, gypsum, ground bones, chalk, common salt, sand, powdered coprolites, &c. Its colour should be buff or brown, according to the amount of moisture, which ought not to exceed 15 per cent. It should have a characteristic but not offensive smell of ammonia, and when burnt should leave a white ash about one-third of its original weight, which should dissolve almost entirely and without effervescence in hydrochloric acid. If it does not dissolve it is very likely adulterated with sand; if it effervesces it is probably mixed with chalk.

A bushel of guano should not weigh more than 56 or

60 lbs., and should contain not more than 2 per cent. of sand. A good sample of Peruvian Guano, with the exception of the sand and moisture referred to, contains nothing which is not of great utility to vegetation, and is fairly classed as a general manure.

Bones in a large state are difficult to adulterate. Bone dust is sometimes mixed with powdered oyster shells, the mother-of-pearl of which may sometimes be detected with a lens. Sand, chalk, salt, and gypsum are also added to increase the bulk. Burnt bones, having lost all their organic part, should experience no further loss on heating. As a rule, bone manure is now professedly mixed with powdered coprolites and other phosphatic substances, forming valuable combinations which are sometimes advantageously applied to the land in conjunction with guano.

Ammoniacal salts, being in many cases the residual product of some manufacture, are seldom sold in a state of purity. The greater the amount of impurities they contain, however, the less valuable must they be in a given weight, for any application where ammonia is the agent sought for.

Sulphate of ammonia being the cheapest ammoniacal salt, is in most common use. Its qualities may generally be judged of by its dry and uniformly crystalline appearance. If a small quantity be carefully heated over a clear fire, it should volatilize, and leave only a trifling, if any residue. Common salt and sulphate of soda are the usual impurities.

The Nitrates of Potash and Soda when sold for agricultural purposes are seldom quite pure, but in examining them to detect adulterations the latitude allowed should not be great.

Pure specimens should produce scintillations when thrown on hot coals; they should dissolve without residue in water, and when treated with chloride of baruim and nitrate of silver the solution should give no precipitate.

Common salt is the most common impurity, and sulphate of soda occasionally added.

Of all the substances used for purposes of adulteration, ordinary water is most frequently used. The large proportion of water which some substances are capable of containing, chemically combined or mechanically attached, increases the weight of a manure, and to that extent depreciates its active value. By weighing a certain quantity of the substance, and drying it on a plate, near the fire, or over a pan of boiling water, the diminution in weight will give the quantity of water which has been driven off. It should be remembered, however, that some manures absorb water from the atmosphere, and so contain ultimately much more moisture than when they were turned out of the hands of the manufacturer.

CHAPTER V.

38. Combination of Manures of Different Characters, so as to Establish an Equilibrium of Action.— Although the substances which form the bulk of all plants are comparatively few in number, almost every plant contains some one or more peculiar to itself. Certain important changes, too, take place during the growth and development of plants, necessitating a constant supply of nourishment through the entire period. It follows, therefore, that a highly concentrated soluble manure may become exhausted and cease to afford supplies, and that perhaps at a critical period of plant life. To guard against this, manures are manufactured containing elements not too readily soluble, or else a combination is used calculated to hold out a supply till

the crop is fully matured. "Reduced superphosphates" are most useful in this way; finely powdered bone is mixed with superphosphates to retard their action, by reducing them to a slowly soluble form; half-inch bone, woollen rags, and long dung, from their slow action, also yield supplies long after the effects of ammoniacal salts, potash, nitrates, and "prepared guano" are exhausted. Attention is also paid in judicious manuring to the specific qualities of the various ingredients applied, so that ammonia and phosphates, potash, soda, &c., may be duly provided to meet the various requirements of the intended crop.

39. Proper Times of Application.—Nitrates should be used only when there is growing vegetation to utilise them—*i.e.*, in the spring. If used in autumn or winter they would be washed out of the soil, but ammoniacal salts would be retained *in part*. As a general rule, phosphates and phosphatic guanos, bone dust, bone earth, and powdered oil-cake, are used to assist and encourage the germination of the seed, other manures being more for the purpose of supplying materials for growth at a later period, and may be used at any period of the year.

40. Favourable and Unfavourable Action upon Different Stages of Growth.—Manures of powerful concentrated action should be carefully kept from actual contact with germinating seeds, or the process of germination may be checked or stopped altogether. At the same time, seeds require nourishment at a very early stage of their growth, as the nutriment in the seed, especially in the case of small seeds, soon becomes exhausted, and they have then to fall back on the soil for their support, which should contain a store in a condition readily available.

41. Desirability of Providing Proper Supply for Final Stages of Growth.—The various chemical changes occurring during the several stages of growth

in our cultivated plants are only complete when the crop is fully matured. A necessity therefore exists for a *continuous* supply of plant food up to the full period of ripening, and a failure here should consequently be carefully guarded against by arranging for the prolonged action of the manure.

42. Proper Relation between Natural and Artificial Manures, when Substitutes and when Supplementary.—Artificial manures are manurial substances prepared or manufactured for application to the land, where it is found that certain essentials to fertility are either deficient in supply or entirely wanting.

Natural manures, on the other hand, are productions of nature applied by man for the same purpose, although lime, the most important, possesses other highly important functions, which are further augmented by burning. Others are nitrate of potash, nitrate of soda, and green manures, the latter exercising also important mechanical effects on the land.

Any *specific* requirement may be supplied by artificials, and their portability renders them useful in outlying districts where bulkier manures could not be carted without great expense. As supplementary manures they may be used as *stimulants* both to the germinating seed and also at more advanced stages of the crop.

43. General Principles Regulating the Selection of Manures.—One of the most important objects in the use of manures is to supply the materials abstracted from soils by the removal of the crops which have grown upon them.

The condition and constituents of the soil to be cropped should also be understood; and with these points in mind a manure may be selected which will most nearly supply the desired fertilizers, and also assimilate as much as possible in its composition to that of the ash of the plants intended for cultivation.

A mixture of different fertilizers in various degrees

of solubility will in many instances best answer these requirements.

44. Manures which Impoverish the Land.—These are *Lime* and *Nitrates*. They act principally by enabling plants to take up ingredients *already existing* in the soil, and which, by their chemical action, they render more completely soluble. The apparent increase of fertility which follows their application is due, not so much to what they impart to the soil, but to the greater facilities which they confer upon it for yielding up the supplies already possessed.

Unless these manures, then, are used in conjunction with others of a more general nature they have a decided tendency to leave the land in a more impoverished condition than before. They are certainly useful in *reducing surplus stores of fertility*, but otherwise their separate application is, as a rule, considered unadvisable.

The use of lime without manure
Makes both the farm and farmer poor.

45. Tillage Operations.—These are carried out for the purpose of assisting the forces of nature in dissolving and breaking up the mineral matter of the soil, and so preparing it for the reception of seed. Good cultivation facilitates the passage of water *downwards* to the drains, and upwards to the roots by capillary attraction, and also keeps the ground clean and free from weeds.

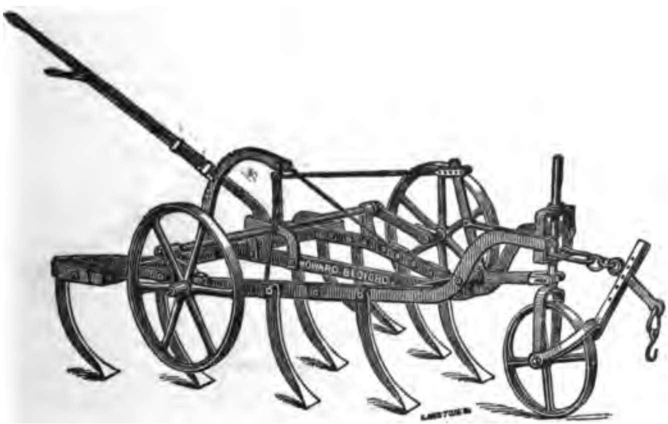
The ordinary operations are known as Ploughing, Grubbing or "Cultivating," Harrowing, and Rolling.

Ploughing inverts a certain section of the soil—deep or shallow, as required—and so brings up a fresh portion to be acted on by the atmosphere. It is this which makes autumn cultivation so valuable, especially on heavy soils; weeds, too, in this way, are eradicated, though in very foul land a second or third ploughing may be necessary.

The definition of a soil most suitable for a seed-bed may

be given in a very few words—clean, fine, deep, moist, and fairly rich. The three first of these conditions may be secured by a deep winter furrow acted on by frosts. This secures a freer soil than when done in spring: the plants are not crippled, nor are their tiny rootlets impeded in their search for nourishment. Ploughing in late spring on a winter furrow is objectionable on heavy lands, as it brings up hard clods to the surface and buries the fine soil produced by changes of temperature, while on light lands it causes loss of moisture by evaporation.

(Fig. 1.)



The Grubber or Cultivator should be used in the spring with deeply-set tines, so as to thoroughly loosen the undersoil, and draw out twitch or couch grass. These tines are set obliquely, and are invariably curved forwards, and differ in this respect from harrow teeth as well as in their length. The process of grubbing stirs

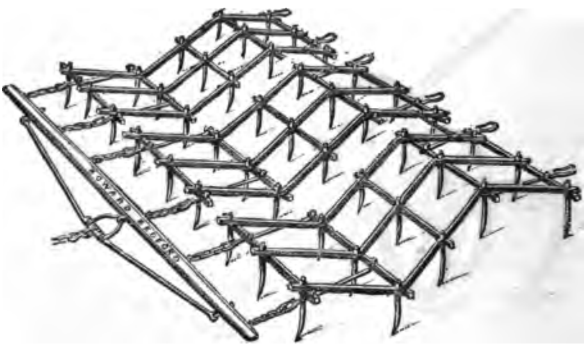
the undersoil; and cross grubbing, though sometimes objected to, ensures the stirring of every part of it.

The advantages of the grubber over the plough in the spring of the year are:—The soil is more loosened at the bottom; the moisture is retained; a finely wrought tilth is secured, and the land is rendered free from weeds.

Harrows are made of different patterns to suit a variety of purposes, and are in effect precisely similar to that of a gardener's rake.

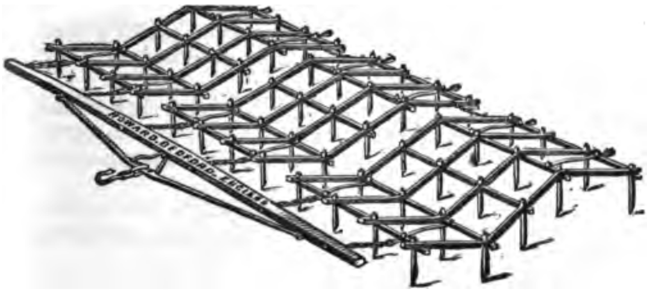
Heavy drag harrows are used to break up rough clods and reduce them as far as possible by exposing fresh surfaces to the influence of the weather.

(Fig. 2.)



Seed harrows level and finish off the ground fit for seed sowing, and also cover up the seed after the drill. They are purposely made very light in order that the seeds may not be too deeply buried. One of the great merits of the harrow lies in the great saving of the seed which may be thus effected by its use.

(Fig. 3.)



Grass-seed harrows are very light, and cover up fine grass and clover seeds at a small depth below the surface.

(Fig. 4.)

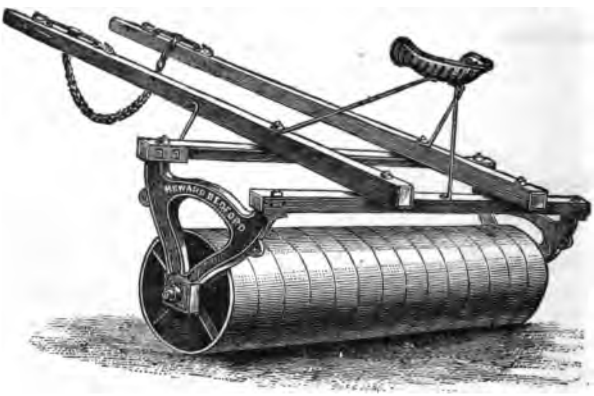
Chain-harrows now take the place of the old brush harrow on grass lands, to brush in fine seeds and manure; they also give a very fine surface where such is required. For covering small seeds the roller merely is often employed, but its use must be regulated by the dampness of the seed-bed.

Rollers are made of different patterns for crushing and pressing the land. In fallow operations it reduces the clods; at seed-time it consolidates the land and checks evaporation; in the early stages of many crops it is used to compress and level the land which a winter's frost may have loosened—thus showing its almost constant operation on the farm.

The plain wooden roller is mostly used for levelling and smoothing the surface for fine seeds. In some parts, as in Devonshire, where granite abounds, stone rollers are used instead of wood.

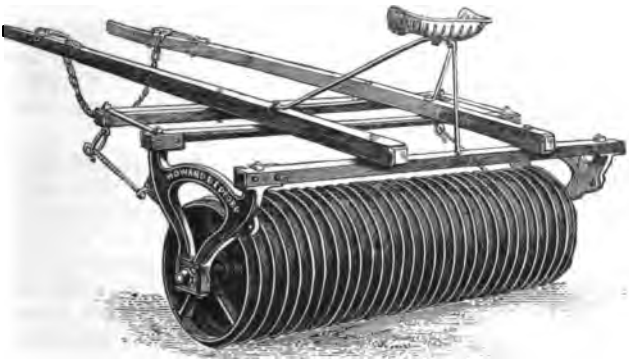
Plain iron rollers, having the cylinder in two or more parts, each moving freely on a common axle, are mostly used for grass lands.

(Fig. 5.)



The Clod-crusher or Crosskill roller (Fig. 6) is the most perfect form of the implement, consisting of a series of wheels, alongside of each other, each having an independent action.

(Fig. 6.)



It is very heavy, and was designed to crush and grind up intractable clods and reduce heavy clays to a fine tilth. They are, however, of equal, if not greater service, as compressors of light soils, before wheat sowing, to roll winter-sown crops in the spring and to consolidate the land where the crops are attacked by the wire-worm.*

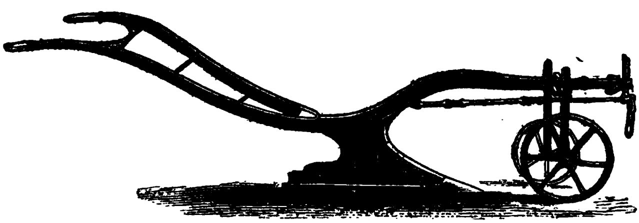
46. Reasons for Ploughing and Mowing Land by Implements.—Economy of labour, time, and consequently money, are reasons all-sufficient for the use of implements in these operations. The many modern improvements and appliances now introduced, and their more effectual action, more than compensate for the outlay.

* The true wire-worm is the offspring of the click-beetle, which lays its eggs in the field, where they hatch, become larvæ or wire-worms, are transformed into pupæ, and from these the perfect click-beetles emerge. Immediately they are hatched from the egg they attack the crops—whether corn, turnips, mangel, potatoes, cabbages, or grass. They are five years in arriving at maturity. They cannot endure sun or dryness, and in severe winters retire deep into the earth. Rooks, starlings, lapwings, pheasants, sea-gulls, partridges, wagtails, robins, blackbirds, and thrushes, but especially *moles*, keep down their numbers.

On most large estates small fields have been thrown together, enabling steam ploughs in many instances to be used with profit and success. The use of implements for mowing enables the work to be done in much less time, giving the farmer a greater chance of "making hay while the sun shines" and doing the work more effectually.

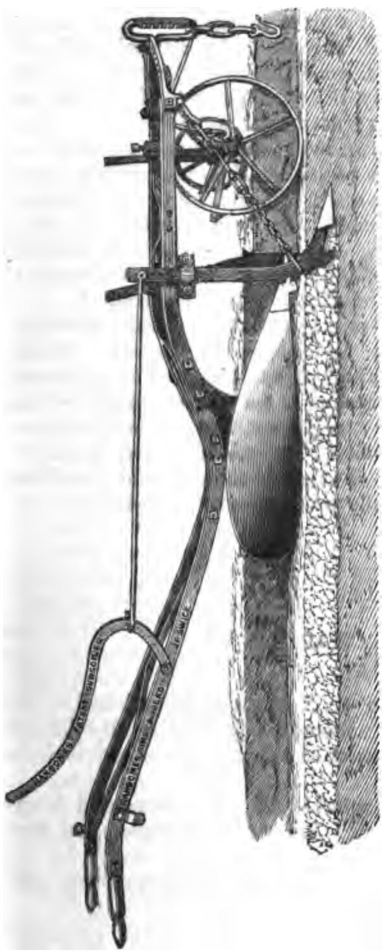
47. Any Changes produced in the Soil, and their Influence on the growth of Crops.—By their more powerful action, implements give a great advantage over hand labour. Where the subsoil is of good quality it may be brought up by trench ploughing and mixed with the ordinary cultivable section, while the subsoil plough (Fig. 7 and Fig. 8) can be set to stir the land effectively to a depth of from 12 to 18 inches, and thus facilitate the drainage, deepen the staple, and open up fresh layers of soil to the roots of plants. By steam-power, subsoiling to a depth of 8 feet has been effectively done.

(Fig. 7.)



The influence on the growth of crops by such improvements is obvious, but its effects are greater on soils resting on hard gravel, or a calcareous subsoil, than on stiff lands, which in case of very intractable clays are apt soon to return to their original condition.

(Fig. 8.)



48 Drainage of the Land when necessary, and its Mode of Action.—The importance of freeing the land from superfluous moisture appears to have been known in times of great antiquity. The Romans understood it and practised it, and the remains of ancient drains in this country show that its utility was recognized from a remote period.

Wherever land is naturally wet, or wherever the flow of water is intercepted in its passage through the soil to the detriment of healthy vegetation, there drainage becomes necessary. Drainage is effected by making in the land channels and water-courses which enable the water to escape from the soil and carry it away

to a lower level. As the water is drawn away from the soil, atmospheric air is drawn in to take its place, and this in itself brings about a great change, both mechanically and physically. The organic acids accumulated by the unhealthy decomposition going on in the stagnant water become changed by the pure oxygen of the air into more healthy forms; dormant matters become soluble and useful for plant growth; injurious compounds are "moved on" by the passage of the water, or practically dissolved; the temperature of the soil is raised, for the sun's rays on dry land are *absorbed* instead of being used in evaporating the moisture; and on properly drained or *ventilated* land the warm rain will carry its heat with it as it percolates through the soil.

The ultimate advantages are—an earlier and more abundant harvest; an enlarged system of rotation becomes possible; a better quality of produce is obtained, the expense of cultivation is reduced, manures are more perfectly used up by vegetation, and the health of both man and beast protected by the improved quality of vegetation and the absence of those humid conditions which are so specially productive of disease.

CHAPTER VI.

49. Crops grown on Various Kinds of Soil.—This point will be best understood by dividing all soils into the two great classes of *heavy* and *light* or *stiff* and *free* soils.

Heavy soils are suitable for grain crops and beans, and are consequently known as "wheat and bean land."

Free soils require a different kind of treatment alto-

gether, and from their suitability for growing such crops have been defined as "turnip and barley soils."

These considerations are the *primary* conditions on which the crops to be grown on various soils are based, with such variations as experience has shown to be best adapted to any particular locality, and to intermediate kinds of soils.

The most retentive clays will best grow wheat and beans with the ordinary fallow crops before mentioned as suitable for such soils.

Strong loams in addition will bear mangels and swedes.

Ordinary loams of good quality are suitable for all crops, with potatoes in sunny situations.

Sandy loams and *sandy soils* will come under the cultivation mentioned as suitable for free soils, rye and barley being the most suitable cereals, and all kinds of forage crops being available.

Thin soils, such as prevail largely on the chalk forma tions, will grow good barley, and are useful for the winter folding of sheep, a system by which these open soils are manured and consolidated for the grain crop.

Peaty soils are well adapted for rape and kohl-rabi, and grow abundant crops of oats with the assistance of liberal supplies of lime.

50. Succession or Rotation of Crops, how Selected and Arranged.—The principle to be kept in view in fixing on a rotation should be the succession which is best suited to draw from the soil the largest net return, while the capabilities of the land are, at the same time, maintained and increased.

As stated in 39, certain plants contain one or more substances peculiar to themselves; some strike deeply, while others are shallow-rooted and obtain their nourishment nearer the surface. On the other hand, the inorganic matters found in soils are present in varying proportions, some containing perhaps very

little of one substance, and an excess of others. These facts, together with peculiarities of climate, will explain why certain soils are specially suited for growing particular crops, and that certain rotations become established in every locality, which experience has decided to be the most profitable to adopt.

51. Conditions Regulating the Selection and Rotation of Crops.

1. The class of land, which is the most important.
2. The climate of the locality—some crops refusing to ripen where others flourish and luxuriate.
3. The substances entering into the composition of our different crops.
4. The kind of root and general habit of the plant.
5. Necessity for both grain and fallow crops for man and beast.
6. Certain diseases appear in crops if rotation be not duly observed—*e.g.*, "clover sickness" and "finger and toe" in turnips.
7. According to Dr. Cameron, "a rotation is necessary, from the fact that each kind of plant differently affects the growth of weeds."

Practical considerations, in addition, are the cleanliness of the land, the continuous supply of food, the division of labour and its distribution through the several seasons of the year, and the state of the markets.

52. Relative Powers of Exhausting or Improving Land.—Some crops are much more scourging than others. Turnips, for instance, remove much potash from the land—as much as 200 lbs. per acre, and nearly 40 lbs. of soda. Oats require five times as much lime as wheat does, while barley, by the adherence of the chaff to the grain, when sold off the farm, takes from the land 26 times as much silica as wheat does.

Again, certain plants are well fitted to precede others; clover, peas, and beans are excellent crops before wheat, as the decay of their roots generates nitrogen for the

nourishment of the wheat crops; they also feed on the upper layers of the soil, while the wheat roots go deeper down. Roots and potatoes, too, are good preparatory crops for grain.

Some crops, on the other hand, have a tendency to injure the soil for other crops—*e.g.*, rye grass is not a good crop to precede wheat; and a succession of similar crops will ultimately exhaust the land by each robbing it of the same constituents.

Experiments on continuous corn growing are being carried out at Rothamsted by Mr. Lawes, who for 34 years has taken a crop of corn from the same land. Where manure has *not* been used at all the average has been for the last 10 years between 11 and 12 bushels per acre, but by liberal and judicious manuring the average has been kept up without difficulty to 36 bushels per acre.

53. Chemical Composition of Different Crops.—The following tables are taken from average analyses, and may be accepted as mainly correct:—

100 lbs. by Weight.	Water.	Husk and Fibre.	Starch and Sugar.	Gluten.	Fat.	Ash.
Wheat	15	15	55	10	3	2
Barley	15	15	55	10	2	3
Oats	16	20	40	10	4	4
Rye	12	15	55	10	3	2
Beans and peas ...	14	10	45	24	2	3
Potatoes	75	3	16	2	1/5	1
Turnips	88	...	8*	1½	1/3	2/3
Carrots	85	...	10*	1½ to 2	?	?
Cabbages	90	...	4*	3 to 3½	2/5	4/5

* Turnips, carrots, and cabbages do not in reality contain starch, but the same proportions here indicated of other substances which, when used as food, serve the same purpose as starch. (Johnson's Catechism.)

54. Good Courses of Cropping—Bad Courses of Cropping.—A good course of cropping will leave the soil in an improved condition for the next crop, not only by abstaining from using the nourishment required by the succeeding crop, but by adding thereto. Bad courses will have the opposite effect, and the produce will also be less abundant. A crop of turnips, clover, or tares not only requires no silicates, and consequently affords time for the disintegration of further supplies, but also increases the amount of humus and ammonia which their numerous leaves absorb from the atmosphere. When such crops, therefore, are fed off on the land or returned in the form of manure, the soil becomes richer than before, and in its additional stores of the various silicates, ammonia, and humus, is in the best possible condition for the growth of corn.

Whatever system of rotation is adopted, a certain latitude should be allowed, especially on large estates, where the soil, aspect, and climate may have considerable variations.

General principles regulating the rotation on stiff soils.—The *bare* fallow is restricted to special places which, from any reason, has got foul and out of order. The remaining fallow crops will be sown or planted with forage crops adapted to heavy soils, such as rape, cabbage, early white turnips, spring and winter vetches, kohlrabi, &c.

All fallows will be followed by wheat sown down with grass seeds in the spring, which will remain in a third year to be again succeeded by wheat, to be again succeeded by beans, while the next year wheat may be taken again, making a very profitable six-year course.

The rotation would then be as follows:—Fallow (bare or cropped); *wheat;* clover; *wheat;* beans; *wheat.* This, however, could only be followed on land in good condition.

For poor clays the following has been recommended:

—Fallow; wheat; clover or beans—to be lengthened by an additional corn crop as the quality of the land rises.

Rotations for light soils.—The Norfolk rotation, or the four-years' course of cropping, is one that has probably been more generally adopted than any other. The course of cropping is as follows:—

1st	year—	Turnips or other roots.
2nd	„	Barley.
3rd	„	Clover or other seeds.
4th	„	Wheat.

The excellence of this system lies in the alternations of grain and fodder, and in the great facilities offered for thoroughly cleaning the land; and in the fact that each crop exerts a favourable influence on that which has to follow. Variations on the Norfolk rotation may be made in districts where the harvest and spring are not too backward, and this without interfering with its salient points.

For instance, a crop of stubble turnips, trifolium, or winter vetches may be taken after wheat, to be fed or cleared off in the spring and early summer in time for roots.

In the South and West and in some of the Midlands very useful supplies of fodder may be secured in this way; but much depends on the seasons, and care should be taken to prevent the land from becoming foul.

Another method of lengthening the four-years' course is by allowing the seeds to remain a second or even third year, giving the following course:—Roots; barley (or oats); seeds; seeds; wheat.

In this case the seeds would pay for a good dressing of manure for second year.

In the northern counties what is called the Northumberland rotation prevails very largely, a system which allows the seeds to remain a second or even third year

to be followed by *oats*, as the wheat invariably comes after the root crop here.

Northumberland Rotation. — Seeds; seeds; oats; roots; wheat.

This system has the advantage of keeping a large proportion of the arable land down in grass, which, at the present price of beef and mutton, has much to recommend it, in addition to the money saved in labour.

An instance of a *Bad Rotation*, in which all good conditions are set aside, may be seen in the following :—

Seeds; seeds (grass or clover); oats; oats; wheat.

Such a course would render the land foul and full of weeds, poor in condition, and produce a very scanty crop from consecutive straw crops and from want of manure.

55. Period of highest Nutritive Value.—Grasses, if allowed to remain uncut till the seed is ripened, lose much of their value, and should be cut for fodder or hay before the seeds are formed and during the time of flowering.

The cereals which belong to the grasses, if intended for fodder, should be dealt with on the same principle: rye and green beans and oats, for instance, are excellent for such purposes. For grain purposes, the most profitable time for cutting wheat in our own climate is two weeks, and for oats one week, before full or dead ripeness.

Roots should be fully matured before being given to cattle, the nourishing properties being then at their maximum. Mangel should be stored till the saccharine properties are developed, which, like that of fruits, is not a vegetable but a chemical process; the same remark applies in a degree to parsnips and carrots.

Other fodder crops, as trifolium, clover, &c., are best before and during the time of flowering, similar principles applying to them, when used as green fodder, as to grass when being cut for hay.

56. Chemical Changes in the Ripening of Grain,

Roots, and Fodder Crops.—In grain crops at the period of blossoming their stems and leaves are full of juices destined to produce the seed. When the blossoms have performed their office in forming the rudiments of the seeds a large portion of the juices of the plant is yielded up to bring them to perfection. These juices consist chiefly of sugar and gluten; in the course of ripening the former is converted into starch, the seed hardens and arrives at maturity, while the sugar not taken up by the seed is converted into woody fibre in the stem.* By thus standing to produce corn the stems and leaves of plants lose about four-fifths of their nourishing matter, which is taken up by the ripened grain.

Roots contain about 90 per cent. of water. The process of ripening reduces the moisture, and raises the sugar, starch, and gluten to the maximum point.

Mangels are much improved by storing, as thereby the saccharine properties are largely developed, and much of the moisture evaporated.

Grasses in ripening undergo similar changes to corn crops, for all cereals are true grasses. These changes are well deserving the attention of the farmer, for, by allowing grasses to remain uncut until the seed is formed, the *sugar* is converted into woody fibre, to the great injury of the hay, which becomes hard and sticky, and affords but little nourishment, while the *gluten* of the plant is exhausted in the formation of the seed, which, for the most part, is beaten out and lost.

57. Necessity for this Action.—By the vital functions of plants the substances of which they are composed are constantly imbibed and changed in the progress of their growth and in the maturing of their fruit. With the growth of the plant the starch, gluten, sugar, &c., also

* Sugar differs but slightly in its component elements from starch and woody fibre. They all consist of carbon and the elements of water—hydrogen and oxygen.

increase, and afford a larger quantity of nourishing matter up to a certain stage, when the whole energies of the plant appear to be absorbed in elaborating the substances necessary for continuing its kind—viz., *the materials contained in the seed*, after which it becomes quiescent, or dies entirely.

58. Influence of Climate on the Perfection of Growth Attainable.—The cultivation of the cereals at the level of the sea extends from 30° to 70° of north latitude, subject, however, to great variations from modifying causes. Near the equator they refuse to ripen under an altitude of 2,000 feet. Wheat requires a bright sun to ripen it, and in the North of England cannot be profitably cultivated at a greater height than 700 feet above sea level. The quality of wheat also varies with the climate, and English-grown wheat is inferior to that from hot countries, which is said to contain more gluten. The period required for the growth and ripening of any crop depends on the total amount of heat received, and consequently varies with the climate.

In Stephen's "Book of the Farm" it is stated that wheat requires 92 days to arrive at maturity in Venezuela, 100 days at Truxillo, 137 in Alsace, 160 near Paris, and 182 days in Scotland. On the Nile, in Egypt, barley ripens in 90 and in South America maize ripens in 92 days.

Barley and rye are grown in Norway in north latitude 71° where they can adapt themselves to the short summer.

Oats succeed well in a moist climate where the mean summer temperature does not fall below 55° and they can stand a much greater elevation than wheat.

Rye can be grown in the moist mountainous districts of Wales at as great an elevation as oats, and also in North Russia, where the subsoil is always in a frozen state, but where the summer sun imparts such intensity to vegetation that 60 days is the usual period which

elapses between the sowing and reaping of the summer crops.

Beans are a somewhat precarious crop—more susceptible of atmospheric influences. The western counties seem too moist and the sun too weak to promote fructification during the flowering stages. In the eastern counties the moisture to the roots is often deficient in spring and early summer, and various diseases consequently set in, and insects often increase the mischief.

Taking this country throughout, we find that the counties of Kent and Essex grow remarkably good wheat, and that in the south a difference of from 10 to even 20 bushels per acre may be reckoned as grown compared with the north.

Turnip.—The climate of Great Britain is admirably suited to the growth of this important crop, though the western and moister districts are better adapted than the eastern and southern counties. A crop of turnips can be raised with much less forcing on the western side of the island, and in Scotland, where the climate is far more favourable; even in the Orkneys, where the cloudy summer will not ripen wheat, very fair crops can be grown.

Mangel-Wurzel.—The climatic adaptations of this vegetable are somewhat different from the turnip. It produces more nourishing and highly elaborated products, and yields a heavier weight per acre. On land highly manured in 1878 the enormous amount of 110 tons per acre were grown of an improved variety sent out by Messrs. Sutton & Sons of Reading, Berks.

Potato.—This tuber possesses a wider geographical range than any other cultivated plant. It can be cultivated from the sea level in the tropics to the height of 13,000 feet in the mountains; and through a variety of moist and dry climates to 75° of north latitude.

CHAPTER VII.

59. Combined Influence of Soil and Climate upon the System of Husbandry, upon the Malting Properties of Barley, the Nutritive Quality of the Flour of Wheat and Oats, the Feeding Power of Roots, and the Various Kinds of Straw.

(*a*) *The System of Husbandry.*—The nature of the soil will furnish the key to the system to be adopted, while the climate will form a consideration only second in importance. The hilly nature of the surface of Great Britain and the circumstance of its being situated between the parallels of 50° and 58° 40′ of north latitude, create great and marked inequalities in the distribution of heat and moisture over its surface, and also in the action of other agents which operate energetically on animal and vegetable organisms. Hence the results of agricultural experience have been greatly modified. In a general way, dairy farms and stock-grazing will be found on lands capable of producing large supplies of rich grass, and these mostly in the western and more humid parts of the country.

The eastern side, being much less humid, we find largely devoted to the growth of cereals. High-lying moors and rough pastures will be devoted to the rearing of cattle for richer districts. The light free soils of the chalk and other formations will be worked as sheep farms, with turnips and barley as their principal crops. On other soils such rotations will be adopted as their nature and that of the climate may permit, bullocks taking the place of sheep, as a rule, on the stiffer soils and lower-lying districts.

(*b*) *On the Malting Properties of Barley.*—The best barley for malting is that which contains the greatest

quantity of starch, which in the process becomes available for conversion into sugar. In appearance, malting barley is short, plump, and white, while "mealing samples," as they are termed, are generally coarse, yellow, and thick-skinned, containing much gluten. The county of Norfolk generally produces favourite malting samples, where the climate is dry, and the soil naturally poor, though rendered very productive by superior farming.

Barley grown after wheat (though a bad practice) gives a better sample for the maltster than the more abundant crop which follows turnips fed off by sheep and enriched by their manure.

(c) *The Nutritive Qualities of the Flour of Wheat and Oats.*—Wheat contains much more gluten than barley, rye, or oats, to which it owes its superiority as a bread-corn. The quantity of gluten, however, contained in each of these different kinds of grain is very variable, and very much influenced by the kind of manure applied to them, the greatest effects resulting from animal manures containing much salts of ammonia. Italian wheats, and those from the South of Russia, are always rich in gluten, and are on that account used by the Italians for making macaroni and vermicelli.

Professor Johnson gives the following proportions of starch and gluten in wheat grown *on the same land* differently manured:—

Manure.	Starch.	Gluten.
Blood	41	34
Sheep Dung	42	33
Horse Dung	62	14
Cow Dung	72	12
Vegetable Manure	66	10

Barley and oats, which contain much less gluten than wheat at all times, are not equally affected by

manures rich in ammonia. The oat is differently constituted from wheat as regards the special requirements of its growth, for it will form and mature its seed under circumstances in which the latter would yield little else but worthless straw. It requires a damp atmosphere where the soil is dry, or a damp and deep soil where the climate is dry.

The flour of oats, or oatmeal, is very rich in those compounds which constitute the muscle-forming principle of the animal frame, and for all exposed to a bracing atmosphere and out-door labour or exercise, no food can be more wholesome or nutritious.

The quantity of the starch in the oat is nearest to that of barley, while, with the exception of Indian corn, no other starchy-feeding material contains so much fat.

For the composition of oats see 54.

(*d*) *The Feeding Power of Roots.*—In turnips, the composition is liable to great variations, like that of all other root-crops and succulent food in general. The difference produced by wet and dry seasons, poor soils and rich soils, slow and rapid growth respectively, far exceed any due to the influence of descent from different varieties. On an average, turnips contain from 88 to 92 per cent. of water, and from 8 to 12 per cent. of dry solid matter, which includes the following constituents: —Sugar, gum, pectic acid, albumen, and similar proteine compounds, cellular fibre, and traces of fatty matters, with minute portions of some less important compounds.

Swedes *usually* contain less water than any other variety of turnips, and a greater amount of feeding compounds. It is stated from experiments made that the increase of live weight in cattle fed in the field on 150 lbs. swede turnips gave 1 lb., but that a similar increase was made on 100 lbs. consumed in a field with a shed to run under.

Mangels when freshly drawn have an acrid principle, which disappears after storing. The increased amount of

sugar is also formed partly at the expense of the pectin. They are much grosser feeders than other root crops.

(*d*) *The Feeding Power of the various Kinds of Straw.* —Much difference exists in the feeding properties of the straw of various kinds of grain, which is modified very largely by the *time of cutting*, for the practice of allowing corn crops to remain uncut till ripe would, so far as the straw is concerned, render it little better than a mass of woody fibre.

Bean straw, or haulm, when well harvested, is considered by Scotch farmers far superior to that of oats, wheat, barley, and rye, and as fodder to be little inferior to good hay; it is apt, however, to produce flatulency: the manure, though, is unusually strong and rich.

Oat straw is preferred by practical feeders to the straw of any other cereals.

Dr. Voelcker found in oat straw as much as 8·31 per cent. of flesh-producing substances; but as the water in this analysis amounted to 43·27 per cent., it was probably cut before the grain was *ripe*, and would, therefore, be much richer than the straw of fully-matured grain. Pea straw contains a high percentage of flesh-forming constituents.

The following percentages show the mean analysis of several sorts of straw:—

	Wheat Straw.	Barley Straw.	Rye Straw.	Oat Straw.	Pea Straw.	Bean Straw.
Flesh Producers	1·85	1·70	1·52	1·80	12·55	84·52
Heat & Fat Producers	67·56	82·12	76·85	65·90	69·45	
Mineral Substances	4·59	5·24	2·93	3·60	6·00	5·58
Water	26·00	10·94	18·70	28·70	12·00	9·90
	100·00	100·00	100·00	100·00	100·00	100·00

CHAPTER VIII.

60. Conditions Regulating the Vital Power of Seeds—Their Character and Quality.—As respects the longevity of seeds, or the duration of germinating power, it is found that different kinds vary to an enormous extent. When entirely removed from the conditions necessary to germination, some seeds of wild plants have been known to lie dormant in the ground for a considerable period, and yet ultimately germinate—charlock, for instance, will suddenly appear on the breaking-up of old grass-land where it has not been seen for years. In woods, the clearing of undergrowth causes hosts of plants to appear which have never been observed before; so also in the sinking of wells and making embankments—white clover in these two latter cases almost invariably springs up.

Most seeds when kept too long produce slow-growing, feeble plants, which are peculiarly liable to various kinds of diseases.

The following points are of importance with regard to selection of seed :—

(1.) It should be fully matured, for during germination the plant depends entirely on the seed for its nourishment.

(2.) All seeds should be perfect and sound, as they produce stronger plants. Corn for bread may be cut before the period of dead ripeness, but for seed purposes maturity should be perfect.

(3.) As a rule seeds should be sown on a soil *superior* to that on which they were grown.

(4.) All seeds should be properly stored in a dry, equable temperature; undue heat and mois-

ture will excite germination which, once checked, can never be induced again.

(5.) Vitality may be arrested or even destroyed by ammonia, or its carbonate, when too near the seed in the soil in a concentrated form.

(6.) The powers of germination may be increased or weakened if the conditions of heat, moisture, air, and exclusion from light be favourable or otherwise; hence the *depth* at which they are placed and the *season* are important elements to be considered, as well as the condition of the seed-bed. The greater the depth the longer the period required for germination, and the less the number of seeds that germinate.

61. Pedigree Influence.—It is a remarkable fact that botanists are not universally agreed on the aboriginal parent form of any one cereal plant. The cereals cultivated in Europe consist of four genera—wheat, rye, barley, and oats. Of wheat the best modern authorities make four, five, or even seven distinct species; of rye, one; of barley, three; and of oats, two, three, or four species. These have given rise to a multitude of varieties, but these quickly assume new habits of life under altered conditions; for instance, summer wheat in three years has been converted into a winter variety, and winter wheat in the same period to a summer variety. These qualities in wheat give it the power to become to a certain extent acclimatised, and it is notorious that the proportion of gluten differs much under different climates, and also the size and weight of the grain, hardness, and time of flowering.

The turnip in its best form is but a hybrid. It belongs to the cabbage tribe, is a native of Great Britain, and is frequently found wild on banks, waste lands, and the borders of fields. The cultivated turnip, with its large

size, uniform shape, firm flesh and nutritive qualities, has been produced by the careful collection of seeds from the original wild forms, planting them in a bed specially prepared and suitable to their germination, forcing forward the plant with manures, singling and weeding them with due care, and keeping the soil in proper order during the process of development. The turnip is capable of producing varieties suitable to different classes of soil, climate, and season. There are at present at least fifty well-known kinds, most of which have good qualities to recommend them; but unless care in cultivation be continually exercised, degeneracy is certain to ensue.

The ordinary fodder grasses are all improved varieties, acquired by care and selection, combined with high cultivation. So far as the principle of *selection* goes, the pedigree of seeds will somewhat resemble that of cattle, and all tendencies to reversion are carefully guarded against by using the best samples possible for seed purposes, combined with favourable conditions of growth.

62. Effect of Age of Seed upon the Form and Character of its Produce, its Rapidity of Growth, and Liability to Disease.—Old seeds germinate with difficulty, if at all, and the process produces a very feeble plant, whose slowness of growth and general want of energy lays it open to the attacks of every enemy; its constitution is unable to withstand successfully any unusual adverse climatic influences, while its liability to disease is much greater than others of a more vigorous temperament. Finally, the produce is inferior both in quality and quantity.

63. Change of Seed, why Necessary.—All our cultivated specimens are what has been termed *derivative plants*. Cultivation has made them different from their parent stock, and *constant change* is necessary to counteract their tendency to degenerate or revert to their

original wild condition. Frequent sowing in the same ground tends to produce a less desirable quality of seed, and the seed from degenerate plants are worse than the parent stock. As the change of soil is limited to the ordinary course of rotation observed, the same purpose is answered to an important extent by change of seed, which as a rule should be produced on land inferior to that on which it is to be sown.

64. Adulteration of Seed.—Seeds are adulterated by the dishonest dealer for the purpose of increasing his profits at the purchaser's expense.

A common practice, unfortunately, is to mix old and inferior seeds, with the new stock. Charlock seed, too, is commonly "killed," and then mixed with turnip seed to increase the bulk. Grass seeds, when old and dull in appearance, have been coloured by an ingenious process, worthy of a better cause, to make them present a bright fresh look. The best way to test all seeds is to try their vitality by sowing a portion in heat, and compare the number sown with those which properly germinate.

CHAPTER IX.

65. Live Stock—Best Kinds of Stock for various Farms—the Economy of Good Stock Management—Ordinary Rules for the Preservation of Health.—British live stock is unrivalled throughout the world, and English cattle excel all other races for the production of both milk and beef, while the sheep, though not producing such *fine* wool as some other races—Australian, Spanish, and German, for instance—in the matter of mutton and wool combined are acknowleged to

be unequalled. English pigs, too, are of such superior quality that they are imported not only by European breeders, but sent to all parts of the world. The same remark holds good with the leading races of the English horse—though it is somewhat to be regretted that some of our very best blood horses are now in the studs on the Continent. Of cattle, Great Britain boasts eighteen or nineteen distinct breeds, twenty-five of sheep, and ten of pigs. The following list will include the leading breeds of each:—

ENGLISH CATTLE.

Durhams or Shorthorns.—These are acknowledged to possess a greater number of good points than any other breed, qualities which have been acquired by careful and methodical selection. No other breed arrives so early at maturity; they are good milkers, rapid fatteners, hardy, docile, and pleasing to the eye. Their colours are various, including white, red, and roan, with long silky hair and excellent shape. They originated on the banks of the Tees, according to Coates's "Herd Book," and to the celebrated bull "Hubbach," calved in 1777, the property of the brothers Charles and Robert Colling, it is the desire of most breeders, either directly or indirectly, to trace back. They are now found throughout the whole of the British Islands, and are eagerly bought up and sent to various parts of the world.

Herefords rival even the shorthorns in the production of beef, but they are poor milkers. The body is red, with white face, breast, belly, and feet, and a line of white which extends along the back to the tip of the tail. They are known throughout the country, but especially in Hereford and the Midlands. They are not so handsome throughout as some other breeds, their hind quarters being rather light and narrow.

Devons in colour are a beautiful rich red, perfect in outline, but rather small. They fatten readily, but give

a moderate supply of milk, which, however, is very rich in quality. They have a peculiarly pleasing countenance; curved, widely-spread horns, and muzzle, eyelids, and ears of a rich yellow colour.

Sussex Cattle are apparently identical in many points with Devons, but darker in colour and heavier in build.

Longhorns are seldom seen anywhere but in the Midlands. Their horns are very long and sweeping, and sometimes have to be sawn off, as they grow downwards and prevent the animals from grazing. They are mostly brindled and black and white in colour.

Norfolk Polls are growing in favour in the Eastern counties. They are a red hornless race.

Sussex Duns are not known far from their own locality, but are valued for their milking qualities.

SCOTCH CATTLE.

Galloway Cattle are yearly sent over the Border in large droves to be fattened on English soil. They are black in colour, without horns, hardy, and well up in flesh.

Angus Cattle are similar in colour and general appearance to Galloway cattle, but possess a larger frame.

Ayrshires are fine dairy cattle, with large heavy udders and hind quarters, but lighter in front. They vary in colour, but white and red are most common.

The West Highland breed do better in the North of Scotland than any other breed. They are also known as Kyloes. They have short muscular limbs; straight back; shaggy hair, black, brindled, or brown in colour; long, up-turned horns, and a bold erect carriage. They will fatten where a shorthorn could not exist, and the meat is of excellent quality. They give but little milk, but the quality is superior.

WELSH CATTLE.

These, as a whole, exhibit a marked family likeness,

and much resemble the breeds of cattle in the mountainous parts of Scotland.

The Pembrokes are a mountain breed; hardy in constitution, and subsisting on scanty herbage, with good flesh and excellent milking properties. Their prevailing colour is black, with deep orange on those parts that are naked; horns long and white.

The Glamorgans, chiefly found in Glamorganshire, are good dairy cattle, but have latterly been much crossed with heavier cattle, such as Herefords and shorthorns.

The Castle Martins are a useful black race, mostly found and valued in their own particular neighbourhood.

CHANNEL ISLAND CATTLE.

These are usually known as "Alderneys," but should properly be described as Jersey and Guernsey cattle, as they offer somewhat marked distinctions in colour. They closely resemble the Ayrshires in appearance, but their milk is distinguished more for its rich quality than its quantity.

Jersey cattle are usually silver grey, dark grey, fawn or smoke coloured, shaded almost to blackness on the haunches, flanks, and neck; nose black, with light hair around.

Guernsey cattle are of various colours, with white noses. Yellow, red, and white are the prevailing colours. Of the four bulls between two and four years old, exhibited at the Bath and West of England Show at Exeter this year (1879), three were red and white and one yellow and white. This breed, too, has attained a very considerable size in the hands of experienced breeders.

SHEEP.

British sheep are classed according to the length of their wool into *long*, *short*, and *middle* woolled breeds, although other important distinctions may be observed, such as the weight of the fleece, the quality of the

mutton, the colour of the legs and faces, and their fitness for certain distinct localities.

Long-woolled sheep have a heavy fleece and carcase; mutton coarse and fat, especially on the back, with white legs and faces. The principal are the Leicester, Lincoln, Cotswold, Romney Marsh, and Bampton breeds.

Short-woolled races yield a light fleece and carcase, and mutton of excellent quality. Their faces and legs are dark brown or black; they will bear confinement in folds, and are best adapted to high and dry situations, such as the chalk downs in the South of England.

The principal breeds are the South Downs, Hampshire Downs, Oxford Downs, Kentish Downs, Norfolk and Suffolk Downs, Dorset-horns, and the Cheviots.

Mountain and Forest Races.—Dartmoor and Exmoor sheep; Welsh mountain sheep; the Herdwickes of Cumberland and Westmoreland; the Heath sheep of the North; the Limestone or Crag sheep of part of Yorkshire and East Lancashire; the Lonks, and the Morfe sheep of the Longmynde, a district in Shropshire.

PIGS.

Professor Darwin lays it down that all known breeds may be traced to two groups. One, the *Sus scrofa* group, descended from the common wild boar; the other descended from the Oriental pig *(Sus Indica)*.

Be this as it may, and the evidence is somewhat conflicting, it is perfectly certain that judicious selections, shelter, ample supplies of nutritious food, and in most, if not all, cases, judicious crosses, have produced what may be called "studs" of modern pigs representing everything worth preserving in the many local breeds which were once identified with almost every county.

The following list will include the best known breeds of English pigs:—

White Pigs—viz., *Large*, *Middle*, and *Small Breeds*—
Yorkshire, Cumberland, Leicester, Suffolks.

Black Pigs—Middle and Small Breeds—Berkshire, Improved Essex, Suffolks.

Red Pigs—Tamworth or Staffordshire Breed.

The large, middle or medium, and small are represented by something like the following weights:—

Large Breed	600 lb.	to	1000 lb.
Medium ,,	400 ,,	,,	500 ,,
Small ,,	200 ,,	,,	300 ,,

Of the foreign element in our improved breeds there are strong reasons for believing that the best of our small white prick-eared breeds owe something to a remote cross with the white Chinese; while the happy introduction of a pair of Neapolitans by Lord Western nearly ninety years ago led to a permanent improvement in our black breeds, especially in the Essex and Berkshire.

HORSES.

Horses are bred to show points most suitable for their various kinds of work. Thus the common cart horse may be divided into three kinds, viz.:—

(1.) The heavy massive dray horse, sometimes 17 hands high, reared in the rich marshes and plains of the Midland Counties expressly for the London brewers, found in the greatest perfection in the fens of Lincolnshire, and, as seen in the London streets, the largest horse in the world.

(2.) The smaller-sized but still tolerably heavy kind of horse—strong, compact, but slow in action—generally employed for agricultural purposes.

(3.) A more active and lighter animal, with some admixture of a lighter breed, or perhaps the descendants of the Flanders coach-horse.

The Suffolk Punch is a well-known breed, much

esteemed for agricultural purposes, possessing the combination of strength, compactness, and activity more highly than any other breed.

Clydesdale Horses have rapidly risen in the estimation of the public, and are said to be descended from Dutch mares crossed by the native breed. They are very powerful, extremely active, and stand 16 hands high. An account of the various breeds, other than for farm purposes, being out of place in a work on agriculture, it is purposely omitted.

Best Kind of Stock for various Farms.—It is an admitted point that certain kinds of stock are suitable for different localities and purposes.

Experience shows that peculiarities of climate, soil, and herbage, exercise a powerful influence on the capabilities of certain races. Thus the hilly districts of Wales and the Highlands of Scotland suit the mountain breeds of both cattle and sheep; the rich lowland pastures of the Midlands bring the shorthorn and the heavy-bodied races of sheep to the greatest perfection; the comparatively dry soil and climate of the Eastern counties fit them for the Norfolk and Suffolk races; and the Devons thrive in the mild, humid climate of their own county. The Shorthorn is admitted to be the most valuable breed we possess, and shows the greatest powers of adaptation to different soils and situations.

In addition to the best *kind* of stock to be selected for any particular farm, the *age* and *condition* of the animals are important points for consideration. Stock are apt to decline in condition very materially if transferred to a climate and soil inferior to that to which they have been accustomed.

The best cows for milking purposes are Shorthorns, Ayrshires, and Irish Kerry cows—though the selection will be modified according as butter or cheese is required. If the former, for increasing the *quality* of the butter Channel Island cattle are unsurpassed.

For grazing purposes Shorthorns, Herefords, Devons, and Sussex, and Scotch cattle are great favourites.

The quality of the land will determine whether grass is best fitted for "freshening," or "finishing" for the butcher, for depasturing dairy cows, or rearing young stock. Generally speaking, rough pastures and high-lying moors are devoted to rearing purposes, the young stock being sold or transferred to better keep for final growth and fattening.

Sheep are the most important stock upon light lands, mountain pastures, and downs, while bullocks occupy the heavier lands and richer pastures.

In short, whatever may be the system of farming adopted, the kind of stock kept must correspond. Some farms will have cattle, some will have sheep, some dairy cows and pigs, and others with a mixed system will require a variety of stock to meet the several requirements of the case.

The Economy of Good Stock Management—Ordinary Rules for the Preservation of Health.—The stock on a farm is kept with a view to profit, and it is satisfactory to know that that which promotes the comfort of the stock also increases the profit they produce. All improved breeds require extra care and *shelter*, as they are tender and delicate.

The proper *ventilation* of farm buildings is an important point, as the want of pure air induces various forms of lung disease.

The supply of *food* should be regular, and calculated to carry on a steady improvement in condition.

A judicious *combination* of food will produce more flesh and fat than the same quantity given separately. Thus 8 lbs. of beans or 6 lbs. of linseed cake will each produce 1 lb. increase in live weight; but actual experiment has shown that 8 lbs. of beans *mixed* with 6 lbs. of linseed cake will give an increase of 4 lbs. in the live weight. The *age* of the animal and its *condition* should

be also taken into account in this mixture of food. Young growing animals require more flesh-forming foods than those whose frames are matured, and which will consequently require more of the fat-producing foods; at the same time the necessity for *both* will be evident.

Health of Cattle.—Nearly all sick animals become so by improper feeding in the first place; and when we consider that the fatting process in former days took place at the mature age of five years, whereas now two-year old beef is by no means uncommon in the market, it will readily be understood that this forcing system has something to do with the ailments of the improved modern breeds. At the same time other causes, such as wet pastures, exposure to inclement weather, and general bad, or indifferent management, are all fruitful sources of disease in cattle.

66. Principles Regulating the Breeding of Stock—The Reproductive Power of Animals, how Strengthened and how rendered Abortive.—Experienced authorities state that for the preservation of a uniform character a certain degree of selection is necessary. Within recent times some of our breeds of domestic cattle have been modified by careful and methodical selection, and the characters thus acquired are strictly inherited.

During the process it has occasionally happened that deviations of structure more strongly pronounced than mere individual differences have been taken advantage of, and in this way new breeds, as they may be termed, have been established.

In every district there is a prejudice in favour of the native breed, and as every year a certain number must be slaughtered, a kind of unconscious selection is even here observed, for the animals possessing qualities, whatever they may be, which are most valued in each district, will be oftenest preserved.

The value of particular "strains" depends on the uniform excellence of the animals that compose them, and

an inferior animal is to that extent an evidence against the excellence of his pedigree.

Respecting the reproductive power of animals, it is well known that constant intermingling of the same blood will render their productive powers very feeble. Instances have been known where the constitution, though carrying the outward points, was too feeble even to support existence, and early death ensued. Similar conditions appear to affect even the mental faculties, according to some authorities. A breeding condition is also often injured by excessive feeding, and while excessive fat diminishes the progeny, excessive leanness makes the progeny good for nothing.

The delicacy of constitution in breeding animals is remedied by introducing fresh blood from another herd, always remembering that a pure male is likely to leave stock more like himself than his ancestors.

67. Pedigree Influence, how Intensified and how Reduced—Good and Bad Qualities, how Controlled.— "Pedigree," as explained by Professor Tanner, "depends entirely upon a fuller development of the principle of 'like producing like' by which cattle produce stock posssessing the character of their predecessors, whether good or bad. The character of a breed becomes more and more concentrated and confirmed in a pedigree animal, and this character is rendered more fully hereditary in proportion to the number of generations through which it has been transmitted. By the aid of pedigree, purity of blood may be ensured and a systematic plan adopted by which we can perpetuate distinct families, and thereby obtain a change of blood without its being a cross. It is evident that any one adopting a systematic arrangement will be able to do this more effectually than any other without this aid."

It is admitted that the male element is more powerful than the female—a circumstance of much importance in the hands of good breeders, for by the use of an

animal possessing the desired points a whole herd may, in time, be modified in the required direction, and this may again be reduced, when desired, by means of an animal whose tendencies in this particular are of a less pronounced, or entirely negative character.

68. Means for Maintaining Constitutional Vigour.—The acknowledged plan is the infusion of fresh blood from a suitable and equally pure strain. Without such a change, breeding from a limited stock cannot be maintained without a deterioration in constitution, size, and powers of fertility.

69. Fixity of Type, how established in New Breeds.—Fixity of type is acquired by matching individual animals and excluding those of an opposite character, and surrounding them with specially favourable conditions. "When individuals of the same variety, or even of a distinct variety, are allowed freely to intercross, uniformity of character, or fixity of type, is ultimately acquired." By judicious pairing of even cross-bred animals it is practicable to establish a new breed. For instance, the Improved Essex pig owes its excellence to repeated crosses with the Neapolitan, together, probably, with some infusion of Chinese blood. So with our British sheep; almost all the races have been largely crossed, except the South Downs.

70. Difference of Breeding In-and-in and Breeding in the Line.—*Breeding in-and-in* means too close interbreeding from members of the same family. The pairing of a father and daughter, a mother and son, or brothers and sisters, if carried on for several generations, is the closest possible form of interbreeding.

Breeding in the line means breeding from selected animals of pure and separate families, all descended directly from a common ancestry.

71. Results from each Process.—*Breeding in-and-in will ennoble* the stock, and impart fixity of type or "character," but, in effecting this, great care is neces-

sary on account of infertility, loss of size and constitutional vigour, sometimes accompanied by a tendency to malformation.

Breeding in the line is a system adopted at once to keep up the purity and to impart fresh constitutional vigour, by the infusion of fresh, but equally pure blood.

The celebrated Improved Essex breed of pigs, raised by Mr. Fisher Hobbs, was maintained in perfection for more than twenty years by judicious selection from the *three distinct families* into which he divided his stock.

72. Causes of Barrenness in Male and Female.—Breeding in-and-in will in time produce barrenness, and it is asserted that there can be found no instance of a breeder who followed this practice during his whole life. A celebrated authority * states that by strictly breeding in-and-in with pigs, the seventh generation in many instances *failed to breed;* in others they produced few that lived, and of the latter many were idiotic, without sense even to suck, and when attempting to move could not walk straight.

Bates's herd of Shorthorn cattle was esteemed the most celebrated in the world, and though he had the most exalted notion of the value of his own stock, within seventeen years, after thirteen years of close interbreeding, he *thrice* infused fresh blood into his herd *on account of their lessened fertility. Sterility also is known to result from changed habits of life,* though these cases are acknowledged exceptions. A breeding condition is often injured by excessive feeding, and excessive fatness diminishes the progeny. Excessive leanness diminishes fertility, and, as a rule, the progeny is good for nothing.

73. Loss of Size in Pedigree Stock.—This is a result of breeding *in-and-in* for too long a period, and can be remedied, as other faults from the same cause, by change of blood and varied conditions of life.

* Mr. Wright, Journal of Royal Agricultural Society, Vol. VII., 1846, page 204.

Climatic conditions of an unfavourable nature will reduce the size of high-bred animals in addition to the deteriorating influence on their other qualities. Food of a less nutritious nature than the animals have been accustomed to will tend to reduce the size of the progeny.

CHAPTER X.

74. On what is the Special Aptitude of Various Breeds for different Conditions of Soil and Climate dependent?—This is largely determined by the capabilities that such breeds and their offspring possess, not only to adapt themselves to their altered conditions, but also to maintain unimpaired, or nearly so, their special characteristics.

75. Influence of Soil and Climate on the Stability of a Breed.—Some breeds undergo considerable changes if the conditions of soil and climate are very much modified. Our massive dray-horses, in a cold, damp, mountainous region would soon decrease in size. Horses that have run wild in the Falkland Islands have lost much of their size and vigour. In a few generations sheep lose their wool in tropical countries; while of those brought from the torrid zone not one has ever lasted out the second year in the Zoological Gardens.

On the other hand, Merino sheep bred at the Cape of Good Hope have been found far better adapted for India than those imported from England. The continent of Australia has been stocked with European domesticated animals, which have increased to an enormous extent.

Some animals, however, are apparently incapable of flourishing under seriously altered conditions. Thus European dogs do not succeed well in India, and no one

has there succeeded in keeping the Newfoundland dog long alive. Climate also affects the fertility of certain breeds.

76. Principles of Acclimatisation.—It has been seen that a serious difference in soil and climate will in time alter the characteristics of an established breed. Nor are these deviations to be wondered at when we remember that in most breeds many of their peculiarities are primarily induced by climatic influences and the nature of their food.

The distribution of groups of species on the earth and their limitation to definite areas is distinctly traceable to a great law of nature. From these definite areas they have not extended, as a general rule, beyond a certain point.

Nevertheless, under the influence of man, some may be removed from their own habitat, and not only exist and flourish, but even destroy the indigenous species, as seen in the myriads of wild horses inhabiting the South American plains, descended from a few introduced by the Spaniards a few centuries ago, and which have thrust out other animals once inhabiting that district.

Asia is the centre of a large number of important groups of quadrupeds that have in course of time spread over most parts of the great Continent, and that have even been transported to America, to the destruction of native tribes. It may be inferred that climate and the nature of the pasture in the different districts of Britain have induced corresponding differences in the cattle. Abundant food given for many generations directly affects the *size* of a breed, and the *climate* affects the thickness of the hair and skin, for the cattle which inhabit the more humid parts of Britain have longer hair and thicker skins than other British cattle. Mountain and lowland breeds of cattle, too, offer such marked distinctions of shape and proportion as suggest at once their fitness for the several situations they occupy. In a

general way successful acclimatisation may be said to depend on the maintenance, or only slight modification, of size, fertility, external covering, and proportions, and general well-being of animals under the altered conditions of climate and soil.

77. Special Requirements for making Land either a Good Dairy Farm or a Good Sheep Farm or a Good Grazing Farm.—All kinds of grass derive their chief value from the quality of the soil on which they are produced; they are more nutritious on rich land than on poor soils, and they are materially influenced by its state of wetness or of dryness. Although most kinds of grasses will grow on various kinds of land, yet they all have their favourite ground, and if transferred from the soil on which they spontaneously vegetate to one of a different nature they lose much of their hardiness and durability. Land devoted to *dairy purposes* is usually that producing natural pasture of a good, but not necessarily *best, quality*, for experience has very decidedly shown that no food is comparable with that of ordinary nutritious grass for the production of butter, cheese, and milk of superior quality and flavour.

Useful additions to such farms are uplands and coarse pastures for turning out the young growing stock, when such are not disposed of as veal to the butcher.

The thin soiled uplands of the downs and mountainous heathy pasture are generally known as *sheep farms.* The turnip and barley crops are essential features, the cultivation of which is materially benefited by the treading and manuring of the flocks. Sheep on such lands are usually of the smaller breeds—South Down, &c. —small of carcase, and with a close but short coat of fine wool. Most of these are polled, but some, as the Dorset breed, have horns.

On good grazing lands the best quality of grass is devoted to "finishing," and the man who has fertile meadows or rich marsh lands may fatten bullocks as

large as he can find them. Large steers, already forward in condition, may, in six or eight weeks, on first-rate grazing land, be transferred from second quality into prime beef fit for the butcher. Land of lower quality will graze or fatten smaller steers, heifers, or "barreners," though the latter are not usually equal to young stock in point of kindliness to fatten.

Among other plans of fattening cattle on such farms is that of turning the grazing steers into the best pasture and stall-feeding them during the close of the year.

78. Principles regulating Special Peculiarities, such as Early Maturity, Rapid Production of Flesh and Fat, Growth of Wool, and Production of Milk.—*Early Maturity.*—In the feeding of animals for the butcher, the grand object has been to establish the supremacy of the *digestive organs* over that of the *nervous* and *respiratory systems*. This not only affords the capability of extracting the utmost quantity of nourishment from the food, but the systematic confinement observed, in course of time, has induced a small lung and inactive sluggish liver—circumstances tending very much to the formation of *fat*, though not to the healthiness of the individual.

Among other constitutional differences Professor Simonds states that in the Shorthorn breed their permanent incisors appear *six months earlier* than in that of the Welsh and Highland hardy cattle.

The rapid production of *flesh* follows from abundant supplies of food containing nitrogenous substances—albumen, caseine, and fibrine—whose special functions are to repair the waste of the body and to promote muscular growth.

Fat is produced from the non-nitrogenous substances in food—starch, gum, sugar, and oil—which also assist in maintaining the heat of the body.

The growth of wool in this country is looked upon as a secondary consideration, compared with the development of the carcase. At the same time, conditions favour-

able to the general health of the sheep will act correspondingly on the quality of the wool, for if the animal be fed with such an abundance of succulent food as to unusually increase its growth, the nourishment thus given also increases the length and coarseness of the pile. When sheep get into poor condition the pores of the skin contract, and permit only wool of a very fine fibre to extrude; when the food once more becomes abundant, the pores again expand, and permit the passage of a larger and stronger fibre. It is important, therefore, to avoid all such conditions and hardships in order to ensure that *uniformity of character* in the quality of the wool usually known as " evenness of fibre."

In composition wool is nearly identical with that of hair and horn. When burned it leaves only from one to two per cent. of ash. In a natural state wool contains from nine to eleven per cent. of moisture, a variable and considerable amount of oily and fatty matter, and a large proportion of sulphur.

The Production of Milk.—As young animals live and thrive for some time on milk alone, it must be evident that it affords all the substances necessary for nutrition, and for this reason milk has been termed a " perfect food."

The secretion of milk is important, not so much to the parent as to the offspring for whose nourishment it is destined. It does not carry off from the system any injurious product of its decomposition,* for it bears a remarkable analogy to blood in the combination of substances which it contains. It has been found that when the secretion of milk has been once fully established, it cannot be suddenly checked without producing consider-

* Being secreted from the blood, anything of an injurious tendency will react on the milk. Thus worrying and over-driving milch cattle affects the quality of their milk. *Extreme grief and rage* have been known to turn the milk of the *human mother* to a poison, resulting in the death of the nursing child.

able disturbance of the general system. The various acts of secretion in the living body are completely removed from the influence of the will. Milk is secreted by the mammary gland, which absorbs the materials from the blood. This gland consists of a number of lobules or small divisions closely bound together by fibrous tissue; to each of these proceeds a branch of the milk-ducts, whose ultimate ramifications terminate in a multitude of little follicles (little pits or bags) about the size (when distended with milk) of very fine pin-holes.

We may attribute the excellence of our cows, with regard to their milking qualities, partly to the continued selection of the best milking animals, and partly to the inherited effects of the increased action of the secreting glands. A wonderful difference may be observed if we compare the udders and their powers of secretion in cows which have long been domesticated, and in certain breeds of the goat in which the udders nearly touch the ground, with these organs in wild or half-domesticated animals. A good cow with us yields daily more than five gallons, whilst a first-rate animal, kept, for instance, by the Damaras of South Africa,* "rarely yields more than two or three pints of milk daily, and should her calf be taken from her she absolutely refuses to give any."

CHAPTER XI.

79. Influence of Breed, Climate, Soil, Food, and Shelter upon the Production of Wool, as affecting its Fibre, its Even Character, its Felting Power, and the Quantity produced.—Sheep have been domesticated from a very early period. Almost every country has its

* Anderson's Travels in South Africa, p. 318.

own peculiar breed, and many countries have several breeds differing greatly from each other, and the several races have become adapted to different kinds of pasture and climate. Youatt has remarked, "In all the different districts of Great Britain we find various breeds of sheep beautifully adapted to the locality which they occupy. No one knows their origin; they are indigenous to the soil, climate, pasturage, and the locality on which they graze; they seem to have been formed for it and by it."

Different races of sheep present constitutional differences in size, fleece, period of dentition and gestation, and capability of withstanding altered conditions of life, in which latter respect they are more susceptible than any other domestic animal.

Great heat seems to act directly on the fleece. European sheep imported to the West Indies, after the third generation, lose the whole of their wool except over the loins, and the animal then appears like a goat with a dirty door-mat on its back. A similar change is said to occur on the West Coast of Africa. All fleeces consist naturally of longer and coarser hair, covering shorter and softer wool, and the change it undergoes is probably a case of unequal development.

Slight Differences in Climate or Pasture are known to affect the Fleece.—This may be seen in soft Australian wools, and has been observed in different districts in this country. In Germany, the Merino sheep are bred and valued almost exclusively for the fineness of their wool, and the result corresponds with the labour bestowed on their selection. "An Austrian fleece has been produced of which twelve hairs equalled in thickness one from a Leicester sheep."

It is a well-ascertained fact that the fibre of wool becomes coarser in the case of highly-fed animals, while on such as are mainly dependent on the natural or spontaneous production of the soil it is of much finer quality.

The sheep in a state of nature inhabits the dry elevated pastures of temperate zones, and their internal economy enables them to take in a considerable bulk of the somewhat innutritious herbage of such districts.

All conditions tending to lower the animal system, such as exposure to heavy rains, snow-storms, severe and continued frost, without shelter, scanty food, and unnecessary disturbances, have a tendency to impair the quality of the wool.

The "Bulletin Association of Wool Manufacturers" remarks that "There is, perhaps, no defect which renders wool, and otherwise good wool too, so absolutely useless for manufacturing, and especially for combing purposes, as tenderness, or breechiness. Except, however, possibly in cases where neglect and mismanagement have been the rule for generations, it is not hereditary; nor is any breed of sheep more liable to it than another."

"Low condition in the flock, followed by more abundant supplies of food, causes the extremities of the wool fibres to be stronger than their centres, and the wool upon the slightest strain snaps in the weakest place—namely, at the portion which grew when the sheep were in the lowest condition. But nothing is so sure to cause a break in the wool, or, indeed, in many sheep, a perfect stripping or shedding of the entire fleece, as want of water." Good fleeces should have as near as possible a uniformity of character—that is, as regards fineness, length of staple, density, and softness.

CHAPTER XII.

80. General Conditions Controlling the Production of Milk—The Quantity and Duration of the Flow, and the Quality of the Milk.—The breed, the individual characteristics, the age, the food, time of the year, and the general management, are points to be considered as affecting the milking qualities of an animal, both with respect to the quantity and the quality of the milk.

Of the various breeds the Shorthorn, Hereford, Ayrshire, Irish Kerry, and Channel Island races are in high repute for dairy purposes, and these may be again divided with respect to their butter and cheese-producing qualities.

The individual characteristics vary very much even in the same breeds, instances being quoted of cows giving 8 gallons of milk per diem.

Mr. Youatt thus describes the points of a good dairy cow:—"She should have a long, thin head, with a brisk but placid eye, be thin and hollow in the neck, narrow in the breast and point of the shoulder, and altogether light in the forequarter, but wide in the loins, with little dewlap, and neither too full-fleshed along the chine nor showing on any part an indication to put on too much fat. The udder should especially be large, round, and full, with the milk veins protruding, yet thin-skinned, but not hanging loose or tending too far behind. The teats should also stand square, all pointing out at equal distances, and of the same size; and although neither very large nor thick towards the udder, yet long and tapering to a point. A cow with a large head, a high backbone, a small udder and teats, and drawn up in the belly, will, beyond all doubt, be found a bad milker."

Food.—It is generally admitted that no food is comparable to that of good natural pasture for milch cows; that the quantity of milk thus yielded is greater, and that the flavour of grass butter may always be distinguished by its superior richness and flavour.

The quantity of milk may be kept up and even sometimes increased by supplies of rich juicy clover, turnips with their tops, brewers' grains, warm mashes, or other food containing much water. "It is also said that if a cow be liberally supplied with whey, a very copious supply of milk is obtained." (Johnson.)

But to obtain milk of the best quality drier food should be given, such as oats, beans, bran, oilcake, and clover hay.

Age.—Two years of age is quite early enough for heifers to breed. In many cases they are seldom kept after they have produced a third calf, as they are then in a better condition to fatten than when older; but they will breed until they are fully twelve years old, and the cows after a second calf yield better milk than with the first.

The Time of the Year.—The period of gestation in the cow is usually 285 days, and the most suitable time for a calf to be born is from the middle of March to the middle of April. The calves at this season are more vigorous, and there is plenty of grass for their dams.

General Management.—The following are important points to be remembered:—

A supply of good water at convenient places, that the stock may not have long distances to travel in order to slake their thirst. Shelter from cold winds and storms, and protection from the sun. Hurrying the cattle at milking time overheats the blood and bruises their udders.

Swamps and boggy lands are conducive of disease, and the pasturage has a deteriorating effect on the quality of the milk. Allowing the cows to "run dry" a sufficient time before calving is amply repaid by the rest to the constitution, the vigour of the calf, and the full

flow of milk after calving. A period of from two to three months is usually considered necessary, but six weeks is oftener the time allowed.

81. How to Increase the Oil of Milk for Butter Dairies, and also the Curd of Milk when Cheese is required.—The same food which promotes the formation of fat will in a milch cow increase the oil of milk in the butter; such foods are linseed cake, linseed, barley, Indian corn meal, and some turnips.

1 lb. of oil-cake per day gives an increase of 1 lb. of milk, or about one-tenth of a gallon, and increases, besides, the richness of the whole. 2 lbs. a day will still further increase the quantity of milk, but will give a peculiar flavour to the butter.

To increase the cheese-making properties of milk, food should be given containing a large supply of gluten, which is very nearly the same in composition and properties as the curd of milk—pease, beans, vetches, clover, clover hay, with oil-cake. According to Professor Johnson, the feeding with whey thickened with meal or grains is said, in the State of New York, to have increased the yearly produce of cheese from a single cow upwards of one hundred lbs.

82. Action of Heat, as in the Process of Scalding Milk.—The principal constituents of milk are held together by a very feeble affinity, and readily separate. When new milk is allowed to stand, the butter or oily matter rises to the surface in the form of cream, and in about twenty-four hours the whole forms a thick mass, and may be separated with very little loss. The separation of the cream is accelerated by using shallow vessels, for thereby the surface is increased, and the most favourable temperature is about 5° to 55° Fah. Devonshire clotted or clouted cream is made by heating the milk, and the process has a considerable effect on its flavour and consistence. The pan containing the milk is placed over a clear fire, which quickly causes the whole of the

cream to rise, carrying with it the coagulated albumen, and probably a portion of the curd. The cream thus produced is very thick, and is easily formed into butter, even by merely stirring it with the hand.

83. Influence of Food and Exercise upon the Yield of Butter and Cheese.—The flavour of the milk is influenced to an important degree by the food consumed.

The herbage of low, shady, and watery situations, as already observed, produces an inferior quality of milk. Mangels increase the quantity of sugar, but given in excess the milk derives an excessively disagreeable, pungent flavour. Turnips and cabbage increase the yield, but often render it extremely offensive. On the other hand, carrots and parsnips enrich the milk without imparting any disagreeable flavour. A small quantity of crushed oats, or barley meal, given with other food, improves the quality, and is considered an economical addition when milch cows are stall fed. Experience has shown that stall-fed animals will do with the grass of a very much less quantity of land than when depastured, and the practice is quite compatible with the production of the finest quality of milk.

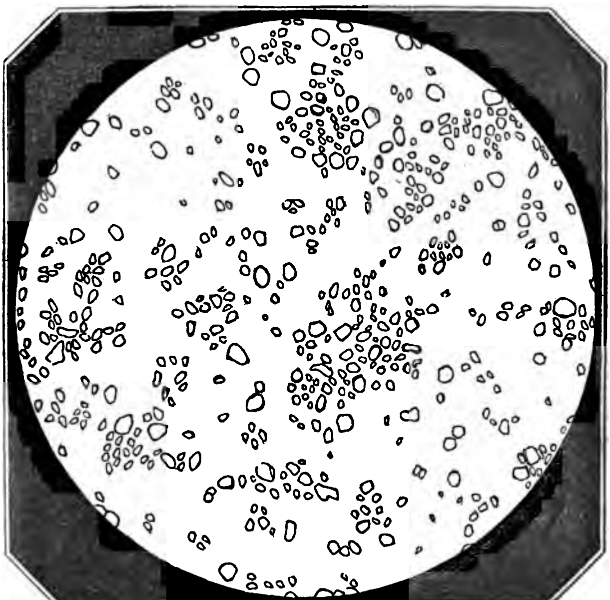
Exercise is essential to milch cows which are stall-fed, from the liability of the animals to take sores in their knees and feet; but at all times the secretion of milk is much encouraged by peaceful, undisturbed surroundings, where the animal can placidly take its food and quietly rest whilst that food is undergoing the necessary changes for conversion into milk.

84. Peculiar Influence of Irrigated or Sewage Grass upon the Dairy Produce.—According to Professor Church, such grass is "sometimes more watery, and occasionally rather saline. In rare cases the hay keeps less well, and acquires, if it does not at first possess, a faint sickly odour and taste. But the influence of sewage grass, properly grown, on milk has been exaggerated."

CHAPTER XIII.

85. Food—Chemical Matters present in various Kinds of Food, in Milk, Green Food, Hay, and Corn, &c., &c.—The composition of milk will vary, on analysis, with food, age, health, and especially with the

(Fig. 9.)



Thin disc of cows' milk, the 120th of an inch in diameter, magnified 400 times in its linear and 160,000 times in its superficial dimensions. The butter globules are floating in the serous fluid out of which cheese is formed.

time which has elapsed since the birth. The following results in milk are from analyses by Playfair, Peligot, Henri, and others:—

COMPOSITION OF MILK.

	Woman.		The Cow.		The Ewe.	The Goat.	The Ass.	The Mare.
Butter	3·55	4·37	3·13	4·6	4·2	3·32	0·11	Trace
Caseine	1·52	1·54	4·48	4·	4·5	4·02	1·82	1·62
Sugar	6·5	5·75	4·77	3·8	5·0	5·28	6·08	—
Salts	0·45	0·53	0·6	·6	0·68	0·58	0.34	8·75
Water	87·98	87·81	87·02	87·	85·62	86·8	91·65	89·63
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

ANALYSES OF GREEN FODDER CROPS JUST BEFORE FLOWERING.*

	Albuminoids.	Fat.	Crude Fibre.	Extractive Matter free from Nitrogen.	Ash.	Water.	Total.
Rich Pasture Grass	4·4	0·8	4·8	9·6	2·2	78·2	— 100
Italian Rye Grass	3·6	1·0	7·1	12·1	2·8	73·4	— 100
Green Rye	3·3	0·8	7·9	10·4	1·6	76·0	— 100
Green Oats	2·3	0·5	6·5	8·3	1·4	81·0	— 100
Mixed Oats and Vetches	2·4	0·4	5·4	6·4	1·4	84·0	— 100
Red Clover	3·3	0·7	4·5	7·0	1·5	83·0	— 100
Alsike Clover in Flower	3·3	0·6	4·5	5·1	1·5	85·0	— 100
Sainfoin in Flower	3·2	0·6	6·5	8·2	1·5	80·0	— 100
Lucerne ,,	4·5	8·0	8·5	9·0	2·0	68·0	— 100
Trefoil ,,	3·5	5·5	6·0	8·0	1·5	75·5	— 100
Vetches ,,	3·5	5·5	5·5	6·0	1·5	78·0	— 100
Field Beans ,,	2·8	3·5	3·5	5·2	1·0	84·0	— 100
Peas ,,	3·0	5·5	5·5	7·5	1·5	77·0	— 100
Rape	2·5	4·2	4·2	3·6	1·5	84·0	— 100
White Cabbage	1·5	2·0	2·0	5·3	1·2	88·0	— 100

* N.B.—These analyses were made just before flowering, in order that the plants might be taken at the time they contained most nourishment, viz., just before the commencement of the formation of the seed.

ANALYSES OF DIFFERENT KINDS OF HAY.

	Albuminoids.	Fat.	Crude Fibre.	Extractive Matter free from Nitrogen.	Ash.	Water.	
Meadow Hay (good)	11·7	2·2	21·9	42·2	7·0	15·0	— 100
,, ,, (prime)	13·5	2·6	19·3	40·9	7·7	16·0	— 100
Red Clover ,, (good)	13·5	2·9	24·0	37·1	6·0	16·5	— 100
White ,, (middling)	14·5	3·5	25·6	33·9	6·0	16·5	— 100
Alsike ,, ,, ...	15·0	3·3	27·0	32·7	6·0	16·0	— 100
Sainfoin	13·3	2·5	27·1	34·2	6·2	16·7	— 100
Italian Rye-grass ...	11·2	3·2	22·9	40·6	7·8	14·3	— 100
French ,, ...	9·5	2·6	28·7	39·1	5·8	14·3	— 100
Perennial ,, ...	10·2	2·7	30·2	36·1	6·5	14·3	— 100

ANALYSES OF DIFFERENT KINDS OF CORN.

	Albuminoids.	Fat.	Crude Fibre.	Extractive Matter free from Nitrogen.	Ash.	Water.	
Wheat	13·0	1·5	3·0	66·4	1·7	14·4	— 100
Rye	11·0	2·0	3·5	67·4	1·8	14·3	— 100
Barley	10·0	2·5	7·1	63·9	2·2	14·3	— 100
Oats	12·0	6·0	9·3	55·7	2·7	14·3	— 100
Maize	10·0	6·5	5·5	62·1	1·5	14·4	— 100
Peas	22·4	2·0	6·4	52·5	2·4	14·3	— 100
Beans	25·5	1·6	9·4	45·9	3·1	14·5	— 100

86. The Different Materials necessary for the Growth of the Body.—The term food or aliment may be applied to all those substances which, when introduced into the living body, serve as materials for its growth, or for the repair of the losses which it is continually sustaining. Animals deprived of these materials diminish in bulk and strength, and death at last takes place after sufferings more or less prolonged. The demands for food are increased by anything which increases the general energy of the system; and the food of animals always consists of substances which have undergone organisation.

All proper foods contain the three following principles:—

1. Nitrogenous, plastic, or tissue-forming elements, which build up and repair the waste of the body.
2. Respiratory elements, which keep up the animal heat.
3. Mineral substances, which contain minute supplies of earthy and alkaline salts for the bones, blood, and muscles.

Water forms two-thirds of the weight of the body, and is both essentially necessary and mechanically useful to maintain, by its solvent properties, the flexibility, elasticity, and smoothness of the muscles and tissues.

87. Maintenance of Heat.—Respiratory, heat-forming, or, as it is sometimes called, carbonaceous or fuel food, abounds in carbon and hydrogen, and it is the combustion of these, by the oxygen drawn into the lungs at every breath, which develops and maintains the heat of the body.

The chief heat-forming foods are starch, sugar, and fats. In starch and sugar carbon only is burnt, the hydrogen being already oxidized, but fats contain a large excess of hydrogen, and this is burnt or oxidized, in addition to the carbon; the fatty substances of food, therefore, maintain a much larger degree of heat than either starch or sugar. Though the fats are essentially heat formers, they doubtless aid nutrition by combining with the albuminous portions of the blood, and thereby increase its plastic or tissue-forming powers.

88. Process of Fattening Animals.—In a state of rest, or nearly so, as when cattle are pastured or stall-fed, the supply of food is greater than the waste, in which case the fleshy or muscular parts increase by the continual accumulation of nitrogenous matters conveyed by the blood, and the excess of the non-nitrogenous part of the

food, over and above what is required for respiration, is converted into *fat*.*

Fat consists of clusters of vesicles or small cells filled with a yellowish unctuous fluid which is secreted into and fills their interior. This fluid congeals or solidifies on cooling after death, forming the suet of the butcher. The ordinary animal and vegetable fats are composed of stearine, palmitine, and oleine, and these contain about three-fourths of their weight of carbon, the remainder being formed of hydrogen and oxygen.

Although rapid growth and the accumulation of fat are opposed to each other, it is very evident that growth and fattening must proceed simultaneously in the case of most of the animals fattened under our present forcing system. It is equally evident that the requirements of a *young* animal put up to fatten will involve a plentiful supply of both flesh and bone forming substances as well as fat producers.

The following points are of immense importance in the process of fattening stall-fed animals:—

1. *With regard to the food itself*:—(a) Amount supplied; (b) judicious combination of different substances; (c) regularity both in time of feeding and the quantity supplied; (d) sufficient water.
2. *With regard to the surrounding conditions*:—(a) Comfort of accommodation; (b) shelter; (c) proper ventilation; (d) degree of temperature (60° Fahr. preferable); (e) perfect repose; (f) thorough cleanliness; (g) partial exclusion from light.

---

* According to Mr. Lawes, starch and sugar have nearly equal fattening powers, weight for weight; digestible cellulose has, for ruminant animals, probably nearly the same value as starch; and fat or oil probably about two and a half times the value of starch, for the purposes of respiration, or the storing up of fat in the body.

89. Constituents of Various Kinds of Food and Proper Classification.—All food may be divided into two parts, the *inorganic* and the *organic:*

The inorganic parts, termed the ash or mineral, is composed of insoluble earthy matters of which lime and phosphoric acid supply the bone; salt and phosphate of soda and others enter into the composition of the blood, while salts of potash enter largely into the juices of the animal frame.

The organic part, or the combustible substances of food, may be classed as the nitrogenised and the non-nitrogenised. The nitrogenised portions of food form the blood and animal tissues; the non-nitrogenous parts maintain the heat of the body and promote the respiratory functions of the animal. The accompanying table shows the different kinds of food and their principal varieties:—

* Nitrogenous or Flesh-forming.		Non-nitrogenous or Respiratory Food.		Mineral Food.
ORGANIC.				INORGANIC.
Albumen Caseine Fibrine Gluten Legumin	Containing Oxygen, Hydrogen, Carbon, and Nitrogen.	Gum Sugar Starch Pectin Fat	Containing Oxygen, Hydrogen, and Carbon.	Lime & Phosphoric Acid. Salt, Carbonate of Soda. Salts of Potash. (Water, &c.)

* "Nitrogenised compounds," "Flesh-formers," "Albumenised and Proteine Compounds," all denote the same thing.

90. Conditions Regulating the Increase of Flesh and Fat obtainable from any given Food or Mixture.—The majority of authorities on the subject agree that a combination of both nitrogenous and non-nitrogenous compounds are essential to promote the healthy performance of the functions of life.

The nutritive value of a food is not *alone* regulated by the amount of organic or inorganic substances which it contains, but by the relation which they bear to the special organisms which they are intended to nourish. The nutritive value of a food, chemically speaking, may be thoroughly well known beforehand, but the *effect* which it is capable of producing is partly a physiological question, and depends on several other circumstances as well. Of these Dr. Voelcker enumerates :—

(1.) *The age of the animals;* for young stock require a more concentrated and easily-digested food than those of mature age, in order to supply muscle and material for rapid growth. Highly nutritious food for old may be, therefore, quite unfitted for young stock.

(2.) *The various kinds of food.* A food given to one animal may not be suitable to another. Thus a cow is fed to promote the secretion of milk, or the formation of fat—functions belonging to the digestive and respiratory systems—but such food given to a horse, with its developed nervous system, and intended to increase its muscular power, may be altogether wrong and out of place.

(3.) *The natural disposition or temper of the animal.* Shorthorns or Herefords fatten better than some other breeds, as the Welsh or Kerry cows; and mountain races of sheep, for instance, would not stand the regimen that the placid Leicester and other heavy races thrive and fatten on.

(4.) *The purpose for which the animals are kept.* Hard-working animals require as much to keep up their strength and repair the daily waste as would render some animals completely fat under favourable conditions.

(5.) *The digestibility of the food*, which varies with (a) the kind of animal; (b) the amount and character of the flesh-forming substances; (c) the sum total of flesh forming substances; (d) the bulk of the food; (e) the form in which it is presented; (f) small proportions of substances with which we may not be even acquainted; (g) the prejudicial substances which the food may contain, tending either to retard the nutrition or flavour the milk or meat.

91. Increase of Feeding Power by Proper Preparation of Food.—The preparation of food is a point of considerable importance in connection with the best modes of economically feeding farm-stock. These preparations have a two-fold object:—

(1.) To facilitate mastication.

(2.) To change certain principles in order to render the food more soluble, juicy, or wholesome—changes affecting the physical or the chemical properties of the food, or both.

The following plans have been adopted:—(1) cutting the hay and straw into chaff; (2) cooking the food; (3) bruising or grinding the various kinds of corn; (4) slicing or pulping the roots. All these plans are economical, and diminish the quantity necessary for nourishment—a most important circumstance to the agriculturist. The small expense of the preparation is largely compensated by the prevention of waste, and from the food being more perfectly digested both by old and young cattle, and those whose jaws are in a bad condition. For cattle, stalks and roots should be cut thick and broad, and for sheep long and thin. Boiled or steamed foods are not, as a rule, necessary for cattle; the first, second, and third stomachs act as the kitchen range, preparing and cooking the food for digestion.

92. Conditions Regulating the Use of Manufactured Materials and Condiments.—The manufactured feeding

materials used on a farm usually consist of the various kinds of oil-cake, which is the dry, compressed husks of seeds from which the oil has been expressed for commercial purposes, but which still contain a certain proportion of oil, varying, according to the manufacture, from 6 to 12 or more, per cent., together with other feeding properties.

These artificial foods are used to supplement the ordinary supplies grown on the farm. In the case of fattening animals in a forward condition, and to other stock at critical periods, especially young stock, their stimulating properties render important service, and, judiciously administered, more than overbalance the cost of purchase.

Condiments (Latin, *condio*, to preserve or pickle) were first introduced and advertised as containing a large amount of nutrition in a very small bulk, and were called in consequence, *concentrated foods*—a great mistake, inasmuch as the animal economy requires food compounds to be at once complex and *bulky*, especially in the case of our ruminating animals.

As to their value, it is generally admitted that their actual feeding properties are far below their cost, but that their general composition (see table) may render them useful from their aromatic* or stomachic proper-

ORGANIC CONSTITUENTS.		INORGANIC, OR ASH.	
Water	11.40	Sand	0.32
Oil	4.06	Phosphates	0.51
Albuminous Compounds	11.47	PhosphoricAcids in combination with Alkalies	0.53
Sugar	17.15		
Starch	46.90		
Woody Fibre	6.22		
Ash	2.80		
	100		

* The aromatic seems to be fenugreek, but accompanied with a bitter substance, probably gentian. Dr. Anderson has shown that their only peculiarity is the aromatic or bitter matters which they contain

ties. These condimental foods are mostly mixtures of several different substances, of which fenugreek, caraway, &c., form part.

Certainly these mixtures at times do good by giving a pleasing taste and smell to the food, and cause cattle to eat with avidity. With all this forcing it cannot be wondered at that cattle fall off their feed and get their stomachs out of order—stomachs which are adapted for rough and almost innutritious substances, and which are neither fitted for, nor accustomed to, great quantities of concentrated feeding stuffs. The majority of articles entering into the composition of some of the cattle spices are not only unnecessary, but really useless and expensive; the simpler they are the better. The following is recommended as containing all that is requisite, giving a fine aromatic flavour to the food, acting as a good tonic, and supplying the alkaline elements:—

CATTLE SPICE.	
Locust Bean Meal	84 lbs.
Indian Meal	2 ,,
Salt	2 ,,
Carbonate Soda	4 ,,
Fenugreek, ground	3 ,,
Carbonate Iron, ground	1½ ,,

93. Advantages Resulting from the Purchase of Food as a Means of Enriching a Farm.—The first object a farmer has in view in feeding stock is the production of meat; the second is the making of manure, the quality of which, in the first place, is regulated by the kind of food the animal consumes.

Nitrogenous foods, such as oil-cakes, produce the best quality of manure, and in this way help to repay the original cost, in addition to their great feeding properties. The accompanying table, extracted from estimations by Mr. Lawes, will show the relative approximate values

of manures obtained by the consumption of one ton of various articles of food :—

	£	s.	d.
Cotton Cake (decorticated) *i.e.*, with the husk removed	6	10	0
Rape Cake	4	18	6
Linseed Cake	4	12	6
Cotton Seed Cake (not decorticated)	3	18	6
Beans	3	14	0
Peas	3	2	6
Indian Meal	1	11	0
Oats	1	15	0
Malt	1	11	6
Barley	1	10	0
Clover Hay	2	5	6
Meadow ,,	1	10	6
Mangel-Wurzel	0	5	3
Swedes	0	4	3
Common Turnips and Carrots	0	4	0

94. Good and Bad Systems of Feeding Stock.—The flesh and blood of animals consist of the same chemical *elements* as those contained in the vegetation from which they are derived, but with a much larger proportion of nitrogen and less of oxygen, which constitutes the principal difference between them.

The same mineral substances which are essential to the production of plants are equally required to form the juices and solids of the animal frame.

The difference between a good and bad system of stock-feeding, therefore, will depend entirely on the judgment exercised in the selection and supply of food, due regard being given to the circumstances of age, condition, and other essential points. The proportion of the food deposited as fat will depend in part upon the surplus which remains after the necessary supply of materials has been afforded to the respiratory system.

From the nature of their stomachs and intestines, oxen are adapted for bulky food, and do not require a concentrated diet. Sheep require a richer diet than oxen, and pigs do best on the meal of grain, such as barley

or Indian corn, as they have not the necessary apparatus for dealing with large masses of crude vegetable fibre.

CHAPTER XIV.

95. Malting of Barley: the Chemical Changes Produced.—Malt may be described as grain in which a portion of the starch has become changed into sugar and dextrine * by an artificially excited germination, which is suddenly checked by the application of heat, when the young root of the germinating grain has been sufficiently developed.

It may be made from any of the cereals, but barley is generally used in this country. Malt contains a larger proportion of sugar and gum than that in the unprepared grain, and also a substance called *diastase*, which has the remarkable property of changing starch into dextrine, and ultimately into grape sugar. The great aim in the malting process is to produce this diastase, which in a pure state is unknown, germination being the only process by which this curious substance is obtained. It is generated in the neighbourhood of the young germ, and probably results from the partial decomposition of the gluten and albumen of the grain.

96. Composition of Barley in its Influence upon the Malt.—The chemical composition of malt and barley widely differs; the variations in the several

* Dextrine ($C_6 H_{10} O_5$) is a clear, gum-like substance, prepared from starch by heating, and so named from *dexter*, the right hand, because its solution directs a polarized ray of light to the right hand when passed through it.

properties being shown by the following analysis by Dr. Thompson :—

BARLEY.		MALT.
Gluten	3	1
Sugar	4	16
Gum	5	14
Starch	88	69
	100	100

Malt thus contains less starch and gluten but more sugar and gum than barley. The amount of diastase in malt is very small, not exceeding $\frac{2}{1000}$, and for that reason has been omitted in the analysis.

Malting barley should contain abundance of starch, and the germ largely developed, a property which enables it to sprout quickly, an important point with maltsters.

Even ripeness is also a merit, which, however, can only be secured by over-ripening, and in this process, unfortunately, in common with other cereals, a portion of the starch is converted into the woody fibre of the husk or bran.

97. Its Action as a Feeding Material.—The general conclusion which Mr. Lawes derived from experiments on this point is, that malt is inferior to barley as a feeding material, but that *semi-malting* either barley or wheat—that is, putting it through all the process of malting except kiln-drying, which drives off all the water, and greatly interferes with its feeding properties, gives a more easily digested and nutritious food, *decidedly superior to either.*

Some years ago, malt, as a feeding material, became a subject of much discussion among agriculturists, by whom it was described as possessing greater feeding

properties than the barley from which it is prepared. Experiments made on rather an extensive scale only showed the farmers to be mistaken; nevertheless, an Act was passed (33 & 34 Vict. ch. 32) allowing "any farmer in Great Britain to germinate grain (free of duty) to be consumed by animals," provided it be neither dried nor crushed, and prepared under the knowledge of the officers of the Inland Revenue. To show how little the privilege is now valued, it may be stated that in 1878 not more than two persons in the whole country applied for the necessary permission.

CHAPTER XV.

98. Relative Value of Natural and Artificial Grasses.—Reckoning meadow hay, of middling quality, as the unit, the following table gives the relative feeding value of the different grasses both as hay and green fodder cut just before or during flowering:—

	Hay.	Green Fodder.
Meadow Grass ......(good)	1·17	0·34
Red Clover...........(good)	1·23	0·41
White „ ......(middling)	1·18	0·31
Lucerne ....(good)	1·42	0·38
Sainfoin	1·12	0·28
Alsike Clover ... (Swedish)	1·20	0·25
Yellow „ ...... (trefoil)	1·28	0·31
Italian Rye Grass............	1·16	0·36
Perennial „	0·89	0·31

99. Conditions Regulating the Fertility of Grass Land.—Grass lands are usually spoken of as *pasture*

and *meadow*; the former is generally of a poor nature, and more hilly situation, while meadow land is of better quality, generally on cold but strong land, and carries thriving grass of which a part is usually reserved for hay. The conditions regulating the fertility of grass land are many and important, among which the following may be enumerated:—

Its Position.—Elevated pastures are usually open and dry, the grass nutritious, short, and sweet, and well suited for sheep; in lower and more sheltered situations damper, better enclosed, and more fit for depasturing cattle.

Age.—The matrix of good turf is formed of vegetable mould, which can only be produced by time, and there is a rich luxuriance in the verdure of a pasture which is only imparted by age.

Variety of Vegetation.—In old pastures herbs of a condimental or medicinal nature abound which are not always present in new pastures, and seeing that the cattle take these herbs as they come in season, their influence must be supposed to be salutary.

Geological Features.—On this, which will include more or less the chemical and physical condition of the land, will depend both the variety and the quality of the herbage to a very large extent.

Management.—Liming and manuring (especially with bones) and proper draining are important to keep down rank grasses, rushes, and mosses, with other precautions, such as grass-harrowing, rolling, &c., in order that the land may not become "hide-bound" and out of condition.

Coarse rank herbage growing in tufts round the droppings of the cattle should be cut down; alternate grazing and mowing will prevent their growth by evenness of feeding. Small enclosures, by enabling frequent changes to be made, will also tend to keep the grass young, fresh, and sweet. Thistles should be carefully eradicated.

Stocking.—On downs and dry uplands it is necessary to keep down the coarse herbage by close sheep-feeding, and thus prevent a sour growth; but in the case of cattle on richer pastures, understocking is better than overstocking, and a change at short intervals is advisable.

100. Agencies which cause Loss of Plant.

1. Stagnant water encourages the growth of mosses.
2. Some kinds of manures and composts favour weeds, *i.e.* miscellaneous herbage, and so indirectly discourages the growth of proper grasses.
3. Insects, wire-worms, &c., bore and feed on the roots: the consequent porosity must be guarded against by heavy rolling.
4. Fungi.
5. Frosts after early warmth.
6. Too frequent mowing for hay thins the plant, particularly on new meadows.

101. Change in the Herbage under the Action of Manure.—Sewage manure is very effective in promoting rapid growth. Ammoniacal manures, such as guano, soot, sulphate of ammonia, and gas liquor, has a similar stimulating effect, but the nitrates, even when applied in small quantities, produce a rapid effect, which is soon seen in the succulent, luxuriant growth and dark green colour of the herbage. Bones, in whatever form applied, by their phosphoric acid supply an element of immense importance, while the grass grown under both this and the application of nitrates is particularly relished, and eaten with the greatest avidity by cattle.

Land that is constantly mown must be frequently manured, or it will be thrown out of heart; for a perfectly thick bottom cannot be maintained, and only a slender crop of hay grown, without a good coating of manure every alternate or third year.

102. Principle upon which Haymaking should be Regulated so as to Preserve the Feeding Properties.—The grasses which compose the produce of the richest natural meadow and pasture amount to between twenty and thirty distinct species, and of these there is not a month, from spring until the close of autumn, but what each, in its particular season, occasions a superior luxuriance of growth, and brings them to ripeness. It is well known that while the flowering stems are shooting up, every species of grass abounds with saccharine matter, and as the seeds approach maturity the sugar becomes converted into woody fibre, while the gluten goes to form the seed. From this it may be clearly inferred that all grasses intended for hay lose their nourishing properties in proportion to the time they are suffered to stand after the period of blossoming.

The proper time for cutting the meadow grasses seems, therefore, to be when the saccharine juices are in the greatest abundance, generally about the middle of June. If the cutting of the crop be much delayed, the best season may also be passed; the plants become withered at the bottoms of their stems; the roots are injured, the after grass is materially lessened in quantity, and the land impoverished.

Principles of Making.—The great object is to preserve the hay for future use in the condition most nearly resembling the grass in its perfect state, and to retain the soluble portion of the grass in perfect integrity. This, however, cannot be *perfectly* accomplished practically, except by means of artificial heat. An analysis by Dr. Thomson shows that 387·5 parts of grass by weight form only 100 when made into hay. The loss in solid nutritive matter on a similar quantity and the consequent approximation of the tender grass to woody fibre is seen by the following table :—

	GRASS.	HAY.
Soluble in Hot Water	28·13	16·00
Soluble in Cold Water	8·21	5·06

In the process of haymaking the following points should be carefully observed:—

1. Preserve as much as possible from rain and dew, for water washes away the soluble salts and other matters.
2. Disturb as little as possible in unfavourable weather: alternate wetting and drying soon render the hay worthless.
3. Overdrying or scorching destroys its virtue, colour, and fragrance; its brittle qualities also are a source of loss and waste.
4. Sufficient drying is necessary to prevent fermentation or heating, a process which, by means of the albuminous matters present, converts the sugar into alcohol and carbonic acid, which may ofttimes be detected as similar to the odour in a brewery.

CHAPTER XVI.

103. Drainage of Land.—The necessity for drainage and its mode of action have been already alluded to in Chapter VI. (49.)

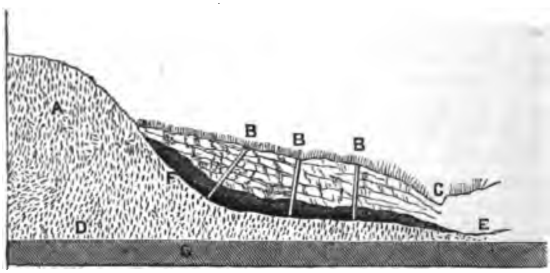
Although the necessity of ridding the land from its superfluous moisture seemed to have forced itself upon

the notice of agriculturists at a very early period, the advantages obtained by drainage in its "thorough" or most complete form have only been recognised within a comparatively recent period. The first movement in carrying out the principle of *deep drainage* was not made till the middle of the seventeenth century. A book published in 1652, by a Captain Blith, entitled "The English Improver Improved," or the "Survey of Husbandry Surveyed," seems to indicate that the author had a fair knowledge of the importance of getting rid of the "bottom water," as in his system the trench was "*to go to the bottom of the cold, spewing, moist water that feed the flag and rush.*"

More than a century after, in 1763 or 1764, a Mr. Joseph Elkington, living at Princethorpe, in Warwickshire, acquired considerable notoriety by the discovery of a mode of draining, which for a long time was highly thought of and extensively adopted under the name of the "Elkington system." He practised his art in all parts of England with much success, and in 1795 received a grant of £1,000 from Parliament—some say £5,000—for describing the principle, on which his practice was founded. Mr. Elkington had, by means of much observation and a keen intellect, arrived at a very correct knowledge of the nature of springs, and the various strata of the earth's crust. He showed that "by cutting a deep drain through the clay, aided, when necessary, by wells or augur-holes, the subadjacent bed of sand or gravel, in which a body of water is pent up by the clay as in a vessel, might be tapped and the water conveyed harmlessly in the covered drain to the nearest ditch or stream." The "Elkington system," when carefully carried out, served the purpose intended by it, but was mainly applicable to sloping land liable to be "drowned by the outbursting of springs," and ignoring as it did the greater evils arising from the flow of water over the surface, and its stagnation in the mass of the soil,

was not of a nature to meet the requirements of a perfect system of drainage. The following diagram, taken from a description of his system of drainage, will clearly explain the stratification and springs referred to:—

(Fig. 10.)

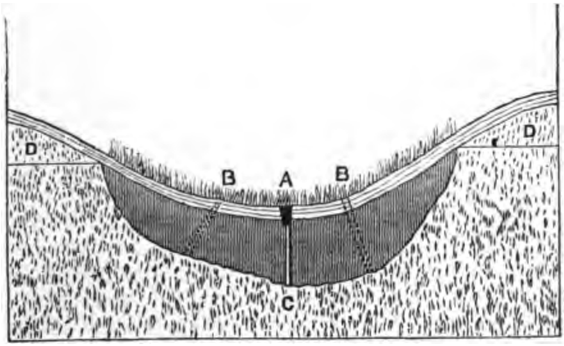


A—High porous ground.
B—Spring.
C—Brook.
D—Sand or Gravel.
E—Tail of Sand or Gravel.
F—Clay.
G—Clay.

Valleys and hollows of a basin-like formation are sometimes kept in a marshy state by springs which are supplied by the surrounding higher land. In this case a deep drain in the lowest ground, reaching the water stratum directly or indirectly by means of wells or augur-holes, will generally dry the whole of the swamp. In such cases it sometimes happens that *below* the upholding impervious bed of clay, or whatever it may be, there exists, at some distance, a dry, porous layer, capable of absorbing any quantity of water which may gain access to it. Copious springs in this case may be made to disappear by simply boring a passage through the layer supporting the water and turning it into the absorbent stratum below.

The diagram (Fig. 11) represents such a basin, and explains the mode in which the drain works.

(Fig. 11.)



A represents the drain which communicates with the porous bed C, by means of the augur hole at the bottom of A. D, dry porous banks, which absorb the rain and discharge themselves by the springs at B B.

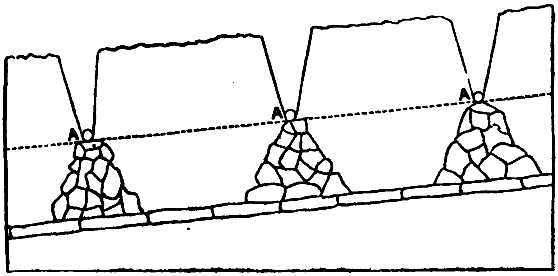
In the year 1823 Mr. Smith, of Deanstone, Perth, introduced his system of so-called "thorough" drainage, which was extensively carried out and extended by Mr. Parkes, a well-known agricultural engineer, who increased the *interval* between the furrow drains, and their *depth* to as much as four feet. This system became known as "deep-draining."

The "combined deep and shallow system," is, as its name imports, a species of compromise between the two. The deep drains are laid at a depth of four feet at varying distances—eighteen or twenty yards apart—and forming an acute angle with these, are shallow drains at a depth of two feet, and some eight yards apart.

At the junction of the shallow with the deep drains a few loose stones are placed, or the mouths of the former are sloped down to allow the stream to run into

the deeper channels which follow the incline or fall of the land.

(Fig. 12.)



A—2 ft. drains.
B—Outfall of 4 ft. drains.

There is a system of drainage, also, which is known as the "Keythorpe system," which is highly spoken of as being both useful and economical.

Of all the systems which have been tried, not one may be said to be capable of uniform application to *all* localities and classes of soils; and before commencing the general work of draining an estate, farm, or even a field, it is advisable that the depth, distance, and fall of drains should first be settled by experiments on a small scale.

Theory of Drainage.—The rainfall is the *primary* cause of wetness in land. In this country the greatest amount of rain falls on the west and the least on the east side of Great Britain.

According to registrations taken at various meteorological stations ranging from the North of Scotland to the South of England, the average difference amounts to upwards of 10 inches per annum. As an extreme case, according to Prof. Ansted,* "at Seathwaite the fall is

* Ansted's *Physical Geography*, p. 283.

127 inches; and a few miles off, at Bishopswearmouth, in Durham, on the other side of the moors, it is only 17 inches." These figures will give an idea as to both average and extreme rainfall in this country.

Of the proportion of rainfall which finds its way into the soil it is difficult to speak with exactitude, so many circumstances of a modifying character having to be considered; but taking one thing with another, upwards of 30 per cent. of the annual rainfall may reasonably be calculated as disposed of by percolation.

Assuming the average depth of rain which falls annually on every acre of land to be 25 inches, we have some 760 tons of water to deal with, annually passing downwards, and carrrying with it more or less fertilizing matters detached from the soil.

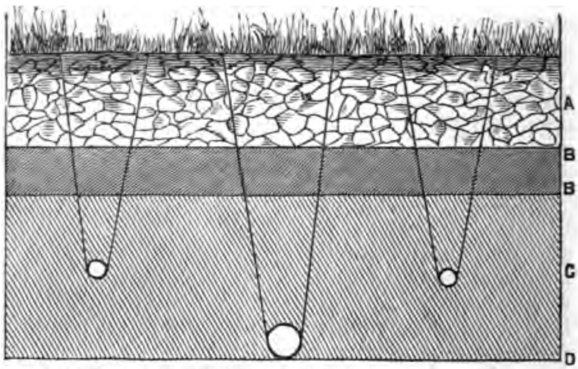
With respect to the question of drainage, soils may be classed in two great divisions—(1) light free soils and subsoils, and (2) clay soils and subsoils. As water readily percolates through free soils, they may be considered as self-draining, and, in fact, are only wet when the drainage is interrupted by water working up *from below*, owing to the presence of an impervious stratum which prevents its escape in any other than an upward direction.

This *diffluent or effluent water* may be got rid of by tapping the springs on Elkington's principle and leading them off by cross drains, or passing them through into a porous stratum below. Drains on light porous soils may be placed at wider intervals than on those of a more retentive nature.

Clay soils and subsoils offer considerable resistance to both air and water, and require the drains to be cut much nearer to each other. The contraction, cracking, and pulverisation of the soil caused by the more frequent breaks in the continuity of the clay strengthens that "reciprocal action" which parallel drains at frequent intervals are known to exert on each other. This action is still further facilitated by deep cultivation.

Paradoxical as it may appear, *water enters a drain from below and not from above.* This will account for the fact that where both deep and shallow drains occur in the same field the deep drains run first and discharge more water than the shallow drains. The following diagram (Fig. 13) illustrates the action of drains. And

(Fig. 13.)



here it may be observed that it is only in degree that the action differs in retentive and free soils. A, represents the cultivable section freed from water by the action of the drains. Section B is the part wet from capillary attraction, C is the part which is super-saturated by water, constituting the "reservoir." The line B is the water table or level of the zone of super-saturation, and D is the water-bearing stratum below which the water fails to force its way.

It will be clearly seen that deep drains which carry off the water in the zone of supersaturation will reduce the water-table to a lower level, and so deepen the dry section which the roots of plants are ready to penetrate, but which they refuse to do when the land is water-logged. Land which is wet may be usually known by

its "cold" character (mists hang round such districts after clearing off from drier localities, and snow remains longer without melting); the presence of certain weeds, water-grasses, rushes, and sedges; the bleached, unhealthy appearance of the grass in pasture; and the stunted, blighted condition of straw on arable lands.

Subsoil ploughs (Figs. 7 and 8) were invented to facilitate drainage, deepen the cultivable section, and encourage the downward growth of roots to the deeper layers of the soil. The subsoiler is intended to break up and stir the close, hard soil below the furrow, which is often rendered impervious by the tramping of horses. In fact, the greatest possible benefit is derived from the breaking up of these hard, gravelly "pans," called in this instance "indurated pans." "Calcareous pans" are sometimes formed by lime, which, in sinking through the soil, forms a hard substratum—a formation which is much encouraged by shallow cultivation.

"Moor-band pans" are hard ochreous deposits formed a few inches below the surface on heath lands. These require to be broken up, as they are quite impervious to water, and in some instances so impracticable that the plough will run upon them as upon a sheet of iron. They are caused by the accumulation of salts of iron in the tissues of the heath, and great strength is generally required to break them up.

Trench ploughing not only stirs the subsoil but brings it up and mixes it with the soil on the surface. Where the subsoil is of good quality, it is a means of improving thoroughly drained land, but on soils of poor quality great caution should be observed in thus bringing to the surface materials of a useless or possibly injurious nature. The safer plan is to gradually deepen the staple by deep ploughing in the autumn, in order that the winter's frost may remedy any unwholesome properties in the thin layer of subsoil thus brought up.

104. Chemical and Physical Properties exerted

upon the Soil and Subsoil. — The great object of draining is the improvement of the condition of the land. To be perfectly successful the conditions are (1) that the rainfall shall quickly sink to the level of the drains and be carried off; (2) that the finely-divided portions of the soil shall not be washed away, but that the water shall be filtered before entering the drain; and (3) that the improvement made shall affect the soil to the necessary depth. These conditions secured, we have as the consequence an increased temperature of the soil, by which crops mature with greater rapidity, together with an increased fertility and better adaptation for all kinds of cultivated crops.

When air is totally or partially excluded by the presence of water stationary in the soil, slowly decaying matters form acrid and injurious products; but a sufficiency of oxygen causes complete combustion or decay, and generates both carbonic acid and ammonia for appropriation by plants.

The carbonic acid acts upon the mineral matters of the soil and assists to bring them into a condition available for plants, while the oxygen converts the injurious organic compounds into others of a more useful form.

The drainage of land also gives an outlet from the soil for any soluble matter which is injurious to vegetation. Wet lands are "cold" because the heat of the sun in falling upon them is expended in the evaporation of the stagnant water, and in the process much heat is required. Evaporation may take place at low as well as high temperatures, but the same amount of heat is required to volatilise or change into vapour any given quantity of water. Calculations have been made which show that in order to evaporate the water from an acre of undrained land an amount of heat would be required equivalent to the burning of from 200 to 300 tons of coal per annum.

In addition to the heat abstracted by the evaporation of water in undrained soils, other physical properties combine in reducing their temperature.

One of these is the low-conducting power of water. The sun's rays may heat the upper layer of water, but being lighter than the colder water beneath, it remains on the surface, and the heat fails to penetrate the soil.

At night, or when a cold breeze sweeps by, the reverse action ensues, for the water, rendered cold on the top, descends by an interchange with the hotter water beneath, which, in its turn, being cooled again, sinks; and thus the whole soil becomes quickly reduced to the same temperature as the external air, and the roots of plants frequently become chilled.

Water also radiates its own heat freely into space, and hence a watery soil is quickly cooled in a cold night by the heat given off into the colder atmosphere.

On the other hand, when soils are drained to a sufficient depth the condition of the soil with regard to temperature is entirely altered. The redundant water does not stagnate, but is immediately carried off. The heat contained in raindrops is higher than that of the air, and this is communicated to the soil. The increased porosity of a drained soil attracts a large quantity of aqueous vapour, thus preventing the parching of plants to a large extent. A new magazine of nutriment is opened up to the roots of plants by enabling the air and carbonic acid to reach the lower parts of the soil, its injurious ingredients are rendered innocuous, and the useful substances liberated.

To sum up briefly, thorough draining has the following effects:—The temperature, or, as we may term it, the climate of the soil is raised; porosity for moisture, though not for *wet*, increased; disintegration is effected, and nutritive soluble substances liberated; atmospheric gases absorbed; injurious compounds in the soil so far altered as to be positively beneficial to vegetation.

105. Respective Action of Water in Motion and when Stagnant.—Stagnant water prevents the admission of air, which causes an imperfect combustion of organic substances, and this, from the insufficient supply of oxygen, generates organic compounds of an acrid nature and highly injurious to vegetation. Water-logged land slowly absorbs but quickly radiates heat, thus keeping the land "cold" and comparatively unproductive. It will be thus seen that stagnant water not only acts *positively* to the detriment of the land, but *negatively*, by preventing the benefical action of the sun and air.

On the other hand, water in motion is followed by the atmospheric air with all its vivifying influences—warmth to the soil and subsoil, from the heat contained in the rain-water (at least in the season of active vegetation); ammonia, carbonic acid, and nitric acid which it has absorbed from the air during its fall.*

Baron Liebig, in his "Natural Laws of Husbandry," thus describes the action of water in a state of motion:—

"If we regard the porous earth as a system of capillary tubes, the condition which must render them best suited for the growth of plants is unquestionably this, that the narrow capillary spaces should be filled with water, the wide spaces with air, and that all of them should be accessible to the atmosphere. In a moist soil of the kind affording free access to atmospheric air, the absorbent root fibres are in most intimate contact with the earthy particles; the outer surface of the root fibres here may be supposed to form the one, the porous earthy particles the other wall of a capillary vessel, the connection between them being effected by an extremely fine layer of water."

---

* Professor Way states that in the years 1855 and 1856, no less than 6·63 and 8·31 lbs. respectively of nitrogen, in the form of nitric acid and ammonia, were deposited per acre, by the rain and snow, exclusive of the quantity deposited in dew and fogs.

CHAPTER XVII.

106. Irrigation.—The first and simplest method of flooding land contiguous to rivers was by making a weir, or temporary dam, across the latter and cutting an outlet into the upper part of the land to be flooded, by which the water was spread over the surface of the dry ground and either allowed to sink or remain to be evaporated by the expedient called *warping*, or by making drains to carry it into the stream at a point below. This process was called *irrigation*.

This expedient of the agriculturist arose at a very early period in hot climates—in the south of Spain, Persia, China, and Egypt, but mostly for the growth of vegetables and corn crops, and has also been found beneficial in temperate climates for assisting the growth of grass and increasing the bulk of hay.

In olden times, in this country, every acre of land which could be irrigated was accounted doubly valuable, it being a very material object to increase the supply of winter fodder, for hay was then a scarce and valuable article, reserved for saddle horses only, and but scantily in use among the generality of light-land farmers. At this time, however, the custom has fallen much into disuse, and irrigation, in a great measure, has become superseded by the introduction of green crops, such as clover, rye-grass, sainfoin, vetches, &c. The cultivation of these invaluable forage plants, with the addition of roots, not only enables the farmer to keep a greater number of live stock, but the alternation of forage and grain crops predisposes the land to yield everything

more abundantly. The practice of irrigation, followed in certain convenient localities, usually repays the labour bestowed upon it by a fresh bite of spring grass, a supply of rank pasture in the autumn, and a certainty of green feed even in the driest summer.

The English counties that excel in irrigation are the following:—*Wiltshire*, with its water-meadows on the Avon; *Hampshire*, with its meadows on the Avon, Test, and Itchen; *Dorsetshire*, possessing some 6,000 acres of irrigated lands, including some very rich in Blackmore Vale, watered by the river Stour; *Gloucestershire*, which has rich meadows irrigated by the Severn, Avon, and Leddon; *Worcestershire*, whose meadows are adjacent to its numerous rivers and small streams, and sometimes also watered by canals which bring the water from a considerable distance; *Devonshire*, which has its hill-side or catch meadows on the borders of its principal streams; and *Berkshire*, which possesses valuable tracts along the banks of the river Kennet.

As these include all the counties noted for water-meadows, it will be seen that but a small portion of England has this kind of meadow at all. Instances certainly may be found in other districts, but these are mainly the introductions of wealthy landowners, and carried out by way of experiment.

107. Various Qualities of Water Employed.—It is remarkable how valuable the application of water is to land when properly applied. By means of irrigation, lands have been raised to the highest degree of productiveness from the lowest degree of sterility.

That fertility arising from irrigation is sometimes the result of manurial matters in the water is proved by analysis: still muddy or turbid water generally produces inferior results compared with limpid waters, which are often the richest.

Water containing much iron is bad, and should be avoided; also those which contain much bicarbonate of

chalk or of chloride of sodium (salt). The plants which grow in the neighbourhood or in contact with the water afford very trustworthy evidence of its properties. As a rule the water is of excellent quality if water-cresses, the aquatic ranunculus, the pond weeds, and the speedwells grow near it. Water of middling quality may be expected where the wild mint grows, Sium cutifolium or S. augustifolium; but if no plants save the mosses and sedges are observable, the quality of the water may be considered bad. Another important point is the soil over which the water flows. That flowing over marls, or supplied from the drainage of low marshy land with a good subsoil, or that flowing over the surface and penetrating to the roots of the grassy turf on hilly surfaces, is good for irrigation, but inferior for this purpose when rising through thick beds of sand, flowing from mosses or peaty soils, from bare hillsides and mountain ranges, or from lakes with sandy margins and edges surrounded with reeds and rushes.

Water from deep wells and springs is rarely good, but the longer it is subjected to the action of the atmosphere the better it is.

In itself, water rarely has a distinctive effect upon good vegetation, the difference between a good and bad water for purposes of irrigation being the difference between their fertilising properties. Even where water is decidedly inferior for the purpose, the bad qualities are got rid of by the action of the air, and flowing over a soil of good quality. The well-known fertilising qualities of the Nile have been proved by Dr. Voelcker to be due chiefly to the suspended matter in the water, shown by analysis to consist of mineral and organic substances in a highly-divided and most effective condition. A specimen of Nile water taken at high-flood contained an amount of organic matter in suspension, which, when deposited on the land, would generate gradually 300 lbs. of ammonia for every 1,000 gallons.

108. Mode of Action.—This is partially regulated by the following attributes of the soil itself:—

Its powers of absorption should enable it to imbibe and retain a large quantity of water for a certain period of time only.

It should possess constituents which readily enter into combination with the fertilising properties of the irrigating water.

Its physical condition should be such as to admit the atmospheric effects, and yet afford a firm root-hold to plants. It must also be borne in mind that heat, air, and light are indispensable agents in the development as well as in the maturation of plants. In a low temperature, secluded from fresh air, or kept in darkness, they become inactive, or languish and die.

Applying these facts to irrigation, it is found that *a thin layer of water trickling continuously over the grass thickens the sward*, by increasing the number, and producing a simultaneous production of blades, rather than by exciting the premature growth of the stem; and *sweetens the herbage*, because there is a constant and equal growth at the bottom. From a consideration of these points, it appears that irrigation prompts the development of grass by defending it from the cold air, by its generation of heat, and by its free admission of every ray of light.

The manurial properties in a given quantity of water are *small;* but by repeated application these accumulate in the soil, partly by infiltration, partly by chemical combination, and are taken up by plants when the water is not applied to the soil. Ammonia, carbonic acid, organic matters, carbonates of lime, magnesia, potash, soda, and sulphur are all held in suspension by water.

It is a remarkable fact that swampy land, which bears very little else than rushes, flags, and the coarsest grasses, if laid into form and irrigated, becomes as fine pasture as any other drier and firmer soil, provided that no water stagnate upon it—that is, *that it be well drained.*

No theory accounting for the effects of *pure water*—that is, water in its ordinary clear and limpid condition as distinguished from sewage—in raising the fertility or productiveness of grass lands, has yet been generally received. The question is to be entertained as one partly of physics and partly of chemistry, and offers a field of interesting experiment and research.

109. Duration of Flow.—The following extracts from the "Journal of the Bath and West of England Society" are from *Professor Tanner's* paper "On the Practice of Irrigation:"—

"The season may be said to commence at the end of September or the beginning of October. During October, November, and December, the water is applied as freely as possible over the meadows. The supply of water may be kept on the land at this time of the year for two weeks, and then turned off to other ground for three or four days. The rapidity with which the land is flooded must depend on the quantity of water to be disposed of, and the extent to be watered. The object should be to keep a *thin coat of water passing gently and continuously over the surface*."

"If very early food be wanted for ewes and lambs, some of the ground may be laid dry for use in the early part of February, or even in January; by the first of March a large proportion would be ready for feeding. The water will, of course, be kept up as described, until a week or ten days before the sheep are turned on the ground, thus giving the grass every opportunity of making its growth and the land of getting firm and dry for stock."

"All the ground which is fed off before April may be watered and fed again before laying up again for grass. As a rule the meadows are fed down and laid up for grass about the first of May; but this system is open to objections."

"As soon as the meadows are clear of hay, the water-

ing may again commence, but the water must not be kept on as long as previously. A week is the usual time, but when the white scum appears, we may know that the water has been kept on too long. In this way there will probably be a good cut of grass ready in five or six weeks. This crop being cut and secured, no time is lost in commencing the irrigation, but as the weather gets hotter, so we are obliged to be content with shorter waterings."

"The growth, however, is more rapid now than at any other time, and by alternately turning the water on and off for two days in succession, we have an incredible rapidity of growth. This produces a valuable aftermath, which is fed during the months of August and September; after this the meadow gutters are thoroughly examined and cleaned, and the land is ready to recommence the duties of another year."

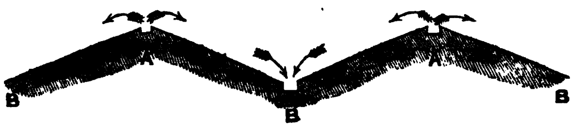
110. Relative Advantages of the Various Systems of Distributing the Water.—The system adopted in laying out and forming irrigation land will be decided in part by the character of the stream which has to yield and carry off the necessary supply of water; and the chance of *economical success* of any plan of irrigation will be partially regulated by the nature of the ground to be watered, and the manner in which its natural facilities are taken advantage of by the engineer. It sometimes happens that a part may be irrigated by the adoption of one plan, while another may present facilities for working a simpler and cheaper system; in such cases the opportunity to consult economy for the sake of establishing uniformity should not be neglected.

Where the object is to utilise stream or river water, the usual plans are two—first, the ridge and furrow system or "bed-work;" and, second, the "catch-work" system, where the utilisation of town sewage is the object aimed at. In the latter case, another distinctive feature has also been effectively practised, viz., the "pipe

and hose" system of distribution, which is usually worked by means of steam. The "ridge and furrow" system is usually adopted in localities where the ground is flat, as in boggy, marshy lands, and lands adjacent to rivers. Here the necessary fall has to be given by special arrangements, often involving considerable outlay —in some unfavourable and extreme cases amounting to as much as £30 to £40 per acre.

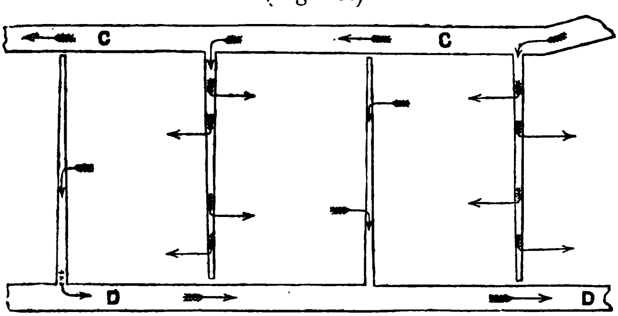
Illustrations of the "ridge and furrow" or "bed-work" system are given in Figs. 14 and 15.

(Fig. 14.)



The land is laid out in a series of ridges which carry along on their summits the irrigating channels, A A, from which the water flows over the sides when the drains B B at the lower parts take and carry it off.

(Fig. 15.)



In Fig. 15 the main feeder is shown at C C, and the channel D D leading off the waters after they have traversed the surface of the irrigated land.

The "catch-work system" is chiefly if not only available where there is a considerable fall, and direct advantage is taken of the natural inclination of the ground—a very small fall indeed being sufficient to enable the water to flow regularly over the land.

The main is filled directly from the stream or river; from the main at the head of the field the leaders are supplied, by means of little sluice-gates or similar arrangements; when the leaders are brimful they run over on both sides along their whole length; the water courses down the slopes, falls into the catch drains, and is carried off into the bottom ditch, and from thence again into the river.

111. Quality of Herbage.—Although liquid manure—sewage—has been applied to all crops with considerable success, and although *theoretically* nothing can be brought against the practice, of a strongly condemnatory character, still, it has been found that there are circumstances which modify very materially the dictates of theory.

The most important points which have been found to be prejudicial to the more general use of sewage are:—

(1.) The clearing of weeds. The stirring and pulverising of the soil which should accompany the growth of "fallow crops" are rendered difficult and uncertain, if not entirely impossible.

(2.) The soil is much "washed" by the application of sewage as usually delivered from the hose and jet in the case of root-crops.

(3.) The "bulk" in manure which is required by all clay lands is wanting in sewage.

(4.) The cereals will not ripen and mature under a frequent application of sewage.

(5.) The tendency of most soils to close up the pores and become incrusted under its application limits its use to certain times of the year, and yet town sewage must be disposed of *somehow* at all periods and in large quantities.

These circumstances naturally reduce the range of crops to which sewage is applicable to forage crops; and of these, grass, and especially Italian rye-grass, is in every way best calculated to repay the cost of sewage application. The quick-growing grass crop will allow the application of fertilising matter as soon as a given quantity becomes exhausted.

According to Dr. Voelcker, "the grass from an irrigated meadow is greatly inferior in point of *nutritive quality* to the grass from natural pastures. Even the grass of water meadows is inferior to natural produce. Bulk for bulk, the poorer the meadow the richer the produce; the more slowly and the more scantily herbage grows, the better and the more nutritious it is."

Mr. J. B. Lawes, on the other hand, states, from experiments made to ascertain the effect of sewage and ordinarily grown grass upon the milking capabilities of cows:—

"There is apparently but little difference between the average *composition* of milk yielded from the unsewaged and the sewaged grass, whether they be consumed alone or in conjunction with oil-cake."

Respecting the *quantity* of milk resulting from the use of sewaged grass, Professor Way says of the experiments tried: "The results show that the quantity of milk obtained from the produce of each acre of land depended very much upon the *quantity* of sewage supplied." See annexed table:—

	Without Sewage.	With Sewage.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.
Tons of sewage applied to end of November.........		1503	3145	4678
Gallons of milk—the yield of each acre	350·7	562·3	807·3	947·4
Value of milk—at 8d. per gallon	£11 13 10	£13 14 10	£26 18 7	£31 11 4

With respect to oxen tied up under cover, and fed on cut-green grass alone, the same high authority states that, judging from the results of experiments made, "grass of the description in question is not adapted for the fattening of oxen without the addition of other food.

Oxen fed upon unsewaged grass alone gave 4 ozs., and those upon sewaged grass 4½ ozs. increase per 100 lbs. live weight per week; "whereas feeding on good fattening food, such oxen should give about 1 lb. increase per 100 lbs. live weight per week."

In the same experiment one of the ten animals fed on the sewage grass weighed *52 lbs. less* at the conclusion than at the commencement.

112. Relative Qualities of Raw and Clarified Sewage.—The sewage in towns under the modern system of drainage becomes so diluted with enormous quantities of water as to reduce in proportion its manurial value; at the same time a sanitary evil is induced by pouring such large quantities of sewage into our streams and rivers.

Town sewage is made up of two classes of substances —"suspended solid matter" and "matter in solution." The elements in town sewage chiefly valuable for agricultural purposes are :—

(1.) *Nitrogen*, which is present as carbonate of ammonia, or in combination with organic matter.

(2.) *Phosphoric acid*, present as phosphates of lime and magnesia, and *insoluble* and *soluble* as phospates of soda and ammonia.

(3.) *Potash*, chiefly derived from the liquid portion and also from the *débris* of the pavements washed into the sewers. Many schemes have been brought forward by which the solid portions only are proposed to be retained for agricultural purposes, leaving the liquid residuum, in a greatly purified condition, to be carried off by streams and rivers.

None of these schemes, however, have been entirely successful, for the simple reason that six-sevenths * of the fertilising elements are in the soluble form, and nearly all chemical authorities agree that the valuable soluble matters cannot be economically extracted from the liquid, and the solid parts are, agriculturally, the most worthless.

"Water has a powerful affinity for the soluble and best portions of manure, hence the inefficiency of costly deodorisers to abstract them from the sewage." Mr. Alderman Mechi, in relation to the "solid sewage" schemes, says:—"The extraction, in a dry condition, of the valuable elements from the sewage, has not yet been satisfactorily accomplished, farmers declining to purchase the residuum at a remunerative price."

As the earth under sewage acts as a great fixative filter, and possesses a stronger attraction even than water for the soluble matters, it robs the liquor of its fertilising ingredients and stores them up for the growth of vegetation. We may hence infer that clarified sewage, losing, as it does, only its "suspended solid matter" and not its "soluble matters," is very nearly as efficient for the land as in its raw or crude condition.

Quality of Crops Grown under its Use.—*Roots* grown under the application of sewage are watery, less nourishing, and deficient in keeping properties.

The Cereal or Grain Crops.—If the plants have passed a certain stage—that is, have got into a grassy condition—the greater produce obtained is in the shape of straw, not of seed. The more the growth is forced in the after stages, the poorer is the sample of seed obtained.

The grasses consequently remain as the best and most suitable crops to which sewage may be applied, and even here experience seems to point out that *quantity* rather

* According to Tables by Hoffmann and Witt.

than *quality* is the form in which the advantage seems to present itself (112).

The following shows the produce of Italian rye grass obtained by liquid manure application:—

			ft.	in.
1st Cutting,	May 22nd	=	2	6
2nd "	June 28th	=	3	0
3rd "	August 10th	=	3	6
4th "	September 17th	=	2	0
5th "	November 13th	=	1	0
			12	0

CHAPTER XVIII.

113. Orchards and Fruit Grounds.—In an agricultural point of view fruit trees are of considerable importance. The apple and pear trees which form our orchards are well known not to be the natural production of any soil or climate, the one being a variety of the crab, and the other derived from the common wild pear, while the numerous varieties of the plum can boast of no other parent than our native sloe. The native wild crab is subject to considerable diversity in the appearance of its leaves, as well as in the colour, shape, and flavour of its fruit. By selection and cultivation, all the valuable varieties known throughout Europe have been produced; and by repeated propagation, new sorts, differing apparently in species, according to the climate in which they have been grown, have been sucessively introduced into the various countries of the north. They do not come to perfection in very warm and tropical climates.

Although the art of propagating fruit trees was known to the ancients, and was practised in this country by the

monks, yet orcharding seems not to have become a considerable branch of rural economy in England till tho reign of Henry VIII. In this reign Harris, the King's fruiterer, is said to have planted the environs of nearly thirty towns in Kent, and from that time the practice was gradually taken up in other parts of the country. The peculiar eminence acquired by the celebrated cider districts of Herefordshire dates from the time of Charles I, when Lord Scudamore retired, after the assassination of his friend the Duke of Buckingham, to Home Lacey, and paid particular attention to the culture of fruit trees, which afterwards became a favourite amusement with the gentlemen of the country.

Although few farms of any considerable size in the country are without an orchard of some sort, yet it is only in our southern and western counties that they are of sufficient importance to become a material object in farming business. The chief cider counties are Hereford, Worcester, Somerset, Dorset, Devon, and Cornwall, and here the nature of the soil and the aspect of the ground are generally attended to. In most other districts, however, the trees appear to be treated with a reckless disregard of all favourable conditions, being as often found open to a northern as to a southern direction, or to any intermediate point of the compass, while the pruning, lopping, and culture are as often left to the browsing of horses and cattle upon the branches within their reach, and the grubbing and routing of the pigs which disport themselves below, when not engaged in barking the stems.

An evident want of judgment, too, must have prevailed in the original planters of many of them, for the trees appear to have been placed at various distances from each other, more according to whim than the dictates of sound judgment.

114. Influence of Soil and Climate upon the Varieties which can be Successfully Grown.—

Unless attention be paid to the proper management of apple and pear trees they will prove in many cases mere encumbrances of the soil, and their strength will be spent in the useless production of wood and leaves.

Apple trees will generally grow where the hawthorn thrives well; but it is only under favourable circumstances of soil and climate that its cultivation should be extensively adopted, for in such it will yield, with a little care and attention, a more abundant and richer produce than could be obtained with the greatest care under circumstances of an opposite character.

The soil for orchards should be well drained if wet, special care being taken to cut off all stagnant water and land springs, for water in contact with the roots has a chilling effect on the vegetation of the trees. If the soil be poor a considerable quantity of compost of manure and good turfy maiden soil should be afforded, and lime will prove beneficial where the soil is not calcareous. The greater portion of the compost should form a layer about a foot below the surface in order that the roots may be diverted from striking too deep; the nearer they are to the surface, where the soil is warmed by the sun's rays, the better. A stratum of coarse stones, rocky fragments, or the like, under a depth of eighteen inches of soil, is recommended as a fertile medium of growth—far superior than double the depth of highly enriched soil.

In sandy soils the crops are earlier and more completely matured than on stiffer land, but for most kinds of apples, and the best sorts of pear trees, a deep, rich, mellow loam is most suitable, but inferior sorts will flourish where the soil will scarcely produce herbage.

The soil should be sufficiently rich to encourage a moderate degree of growth, without stimulating the plant to premature exertion, which always induces disease.

The situation of an orchard should be the southern or south-eastern slope of a gently-rising ground, neither too elevated nor too low, for the trees thrive better in moderately high and open spots than in low situations. Shelter from prevailing winds is highly beneficial, but if sufficiently high there is less danger from frosts in the spring and early summer.

115. Essential Conditions of Healthy Growth, and Production of Fruit.—These considerations involve attention to the following points:—

(1.) *Aspect*, which should ensure shelter from winds and frosts, and exposure to the sun.

(2.) *Soil* of proper quality and texture, with suitable depth and subsoil.

(3.) *Drainage*, in order that all superfluous moisture may be carried from the roots.

(4.) *Distance from tree to tree*, in order to admit the necessary degree of light, air, and heat, and prevent crowding.

(5.) *Pruning of both roots and branches* when such operations become necessary.

(6.) *Selection of sorts which are specially suited to the neighbourhood.*

116. Chemical Conditions which Regulate the Selection and Ripening of Fruit for the Manufacture of Cider and Perry, the Fermentation of the Juice, and the Preservation of its Quality.—Cider is simply the expressed fermented juice of ripe apples, and perry is obtained in a similar manner from pears.

The apples are ground down in a mill and then placed in large horse-hair bags, through which the juice flows under the weight brought to bear upon them by the cider-press. As is well known, apples vary very much in quality and keeping properties, some being suitable for cooking purposes, others for table fruit, while a large number of varieties are fit only for making cider.

At whatever period the manufacture of cider is carried on, it is always essential that the weather be cold, or even slightly frosty, to counteract the tendency to a too rapid fermentation. The fruit should be sufficiently crushed as to bruise the seeds or "pips," so that their albuminous principle may be fully extracted, for this exercises a very important influence on the strength and flavour of the liquor.

Cider ought to possess a rich amber tint; if pale it indicates weakness, or a defect in the fruit. It is said that at least two varieties of apple ought to be employed—one of a sweet luscious quality, the other rough and astringent. Some makers use the produce of an orchard indiscriminately, hence the various qualities.

Selection of Fruit.—The kinds of apples generally used for cider are not those suited for the table, as the former are possessed of a certain degree of astringency approaching to harshness. The strongest liquor is certainly produced from fruit of that quality, but it is generally "rough" and "hard," and not usually liked by persons unaccustomed to it. The colour of good cider fruit is invariably red and yellow, the green affording a liquor of the poorest quality. Small apples, if equal in quantity, are always preferred to those of a larger size, as containing juice of a higher flavour. Another important reason is that small apples contain a larger proportion of *core*, for it is that which chiefly imparts the fragrance, and cider made from pulp alone is found to be comparatively weak.

Ripening of Fruit.—The fruit should remain on the tree as long as is possible without injury from decay or frost. The perfect maturity of the juice is an important consideration, and such is the susceptibility of apple-juice, that the colder the weather, short of actual frost, the more quiet and equable will be the fermentation. It is advisable that every sort should be gathered separately, on the *finest* and *driest* occasion that offers

itself, and kept till perfectly mellow. For this purpose it is usual to place the fruit in several heaps, about a foot in thickness, and fully exposed to the sun and air. The evaporation they undergo reduces the amount of its watery particles, and additional strength and superior flavour are acquired by the process as the further ripening develops the saccharine matters.

Fermentation is a gaseous change that takes place in certain substances, and is of three kinds:—*Vinous*, producing alcohol; the *acetous*, producing vinegar; and the *putrefactive*, which is that spontaneous decay and decomposition which is unaccompanied with the production of alcohol or acetic acid, and consequently has nothing whatever to do with the question of cider-making. In distinguishing between the best and the rough qualities of cider, the first may be described as that sweet mild liquor which can only be obtained by careful attention to the fruit and by unremitting attention during the process of fermentation, and the second that strong, harsh liquor that results from an active and perfected fermentation. The latter kind is certainly preferred by the people of cider districts, but is disliked by others unaccustomed to it.

The average density of apple-juice is about 1,070 to water at 1,000, and this density or specific gravity of the juice is the index of its future strength.

In the manufacture of cider the expressed juice of the fruit is in a foul and turbid state, and can only be purified by undergoing vinous fermentation. It is, for this purpose, put into sound, sweet casks, and in a day or two, according to the temperature and the ripeness of the fruit, it begins to work or ferment, and with this action the critical period of the process begins. *Rapid fermentation* is fatal to the quality; and yet so great is the difficulty, occasioned by the natural tendency of the juice to run into rapid fermentation, increased by atmospheric changes not always under control, that the best

and most practised makers vary in their description, and are at a loss what process to recommend.

The common practice of allowing fermentation to proceed too far will cause the cider to be harsh and rough or "hard." According to Liebig, apple juice "contains within itself the principle of disturbance, when its state of quiescence is brought into one of motion."

But, to produce a first-class cider, the maker must employ a juice of the greatest possible density, conduct the fermenting process to a certain stage, and then check it at once, and effectually.

The usual means for checking the fermentation are:—(1) boiling the juice; (2) changing the juice into fresh casks—a process called "racking," and which separates it from the dregs; (3) sulphuring or strumming, which consists of the introduction of the fumes of burning sulphur into the partially-filled cask by means of a piece of burning paper dipped in brimstone, and then filling up the vessel—a process to be repeated if necessary: this is sometimes called "matched" cider; (4) the use of a small portion of sulphate of potash—a drachm will be sufficient for a pipe of cider.

When the process of fermentation has subsided, the cider is usually "fined" or cleared by isinglass or some other preparation; drawn carefully off and turned into another cask; and when every symptom of fret is wholly subsided, it is then considered fit for market.

Bottling should take place at the end of a year, a time necessary to make best cider fully matured.

With regard to the manufacture of perry, it is in all respects so nearly similar to that of cider, that no further description is necessary. The pears which are preferred for the purpose require an assemblage of qualities rarely found in the same fruit. "It should contain a large portion of sugar, or its juice can never possess sufficient strength; and unless it be at the same time extremely astringent, the liquor produced from it will become acid

whenever it ceases to be sweet. In the latter state it will agree with few constitutions; in the former with none."

By careful attention to the selection of fruit and to the manufacture, especially during the process of fermentation, a very excellent and superior beverage is made in Devonshire, having many of the properties of the finest champagne—clear, sparkling, effervescent, and of delicious aroma.

CHAPTER XIX.

117. Diseases of Plants.—In an agricultural point of view, two main classes of disease may be said to exist in our cultivated crops—the one arising from derangements of the conditions necessary to healthy growth, the other from injuries directly inflicted by other organised beings. The first class will comprise what may, in a general sense, be considered as internal disease; the latter injuries derived from the depredations of beasts, birds, insects, or from parasitical development.

It is very clear that certain conditions of soil, temperature, and other inorganic agencies are not merely necessary to the healthy development of particular plants, but that any great derangement of these conditions, or of any one of them, is sufficient to prevent their growth. These changes are not always open to our senses and powers of observation, and consequently diseases may

be set up in plants which come within our notice without our being able to assign a cause, or suggest a remedy.

The following may be enumerated as points whose derangement may seriously affect the well-being of our cultivated crops :—Temperature, light, air, water, soil, and to a certain extent electricity.

118. Bunt or Smut-ball, Mildew, and Blight in Corn Crops.—*Bunt or smut-ball*, the most formidable disease, perhaps, to which wheat is subject, arises from the attack of a parasitical fungus. Technically, bunt is termed a *coniomycetous fungus* (Gr., a cone mushroom), that is, one of a sub-order of sporiferous fungi in which the spores or seeds are single.

Bunt is generated in the ovarium of wheat, and a few other of the cereals, at a very early stage of growth, before even the ear is free from the sheath. The extent to which smut-ball formerly prevailed was sometimes quite calamitous ; but effectual remedies have been discovered which have very nearly eradicated it by destroying the vitality of the spores, for they very readily adhere and germinate on grains hitherto entirely free from their attacks.

In years gone by salt, lime, Glauber's salts, and other substances were used as "dressings" for seed corn to prevent the growth of smut-ball, but the general remedy now is sulphate of copper (blue vitriol).

Blight or mildew.—The editor of the "Gardener's Chronicle," in an answer to some correspondent as to the nature of blight, says, "It is a sunstroke or a frostbite, a plague of insects or of fungi, a paralysis of the roots, a gust of bad air; it is wetness, it is dryness, it is heat, it is cold, it is plethora, it is starvation—in short, it is anything that disfigures or destroys the foliage."

It may be further defined as "a generic name commonly applied to denote the effects of disease or any

other circumstance which causes plants to wither or decay."

The definition may be applied to different forms of mildew, rust, or the ravages of minute moulds and of some destructive insects.

Wheat mildew is due to the growth of a parasitic fungus, and, though rare on other cereals, is found most extensively on grasses and reeds. Although the wheat-crop, be the season what it may, is seldom entirely free from its attacks, it is only in such atmospheric circumstances as are favourable to its growth that it arrives at such a state as to become injurious.

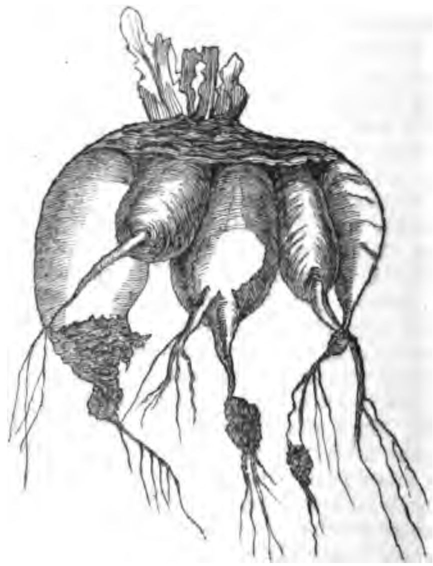
119. Finger and Toe, Clubbing and Curl in Root Crops and Cabbages.—*Finger and toe* is a disease or malformation in the turnip bulb, which, instead of taking the usual form of growth, with one main root, throws out various appendages. These roots become woody, circulation ceases, and the excrescences which are formed decay and emit most offensive effluvia, which attracts flies, beetles, and various insects to deposit their eggs. In a short time these hatch and fill the excrescences with maggots and different larvæ. It generally arises from some peculiarity of the soil when it is not well mellowed, and from injudicious cropping. It is a disease which does not occur on well-drained soils, and under our improved rotations is but seldom met with.* Anbury is but another name for "Finger and toe," an illustration of which in a highly aggravated form is given in Fig. 16.

Clubbing is a disease in cabbages, brocoli, turnips, and other nearly related plants, and is caused by the larva of an insect. The enlargements at the bottom of

* Dr. Voelcker, in his Report (1876) to the Royal Agricultural Society of England, traced the disease of Anbury or Fingers-and-toes, which did much damage in certan districts, "to the deficiency of available potash and lime in the land upon which the turnip-crop was much affected by that disease."

the stems become tuberculated with globular or elongated warts (see excrescences in Fig. 16), each of which

(Fig. 16.)



contains one, or sometimes two, larvæ in separate cells. The plant in consequence becomes unhealthy and peculiarly liable to decay. It is most prevalent in ground which has repeatedly been cropped with species of the brassica or cabbage tribe.

The usual remedies are change of cropping, thick dressings of wood ashes, charcoal, dust, or marl, deep trenching, and the use of quick-lime, and dipping the roots of cabbage, brocoli, &c., into a paint composed of one gallon of fresh soot mixed with 1 lb. of saltpetre before planting.

Curl is a disease in potatoes, and its appearance is thus described in a work on the "Diseases of Potatoes:"—

"The curl is an imperfect formation. Soon after their first appearance, the shoots become curled, and make but little progress afterwards; sometimes, indeed, they disappear altogether. Some, however, remain nearly stationary, either not producing blossoms at all, or only very weak ones, which soon fall off and yield no seed. They produce no tubers, or only a few minute ones, which are hard and unfit for food. These, however, when set, do not always produce plants infected with the disease."

The contraction of the leaves is probably caused by the parenchyma * of the centre being multiplied, while that towards the margin remains stationary, so that they retain their greenness and juiciness, though curled and crumpled. In some soils curl does not appear, while in others, especially those that are rich, and have been long under cultivation, it is often prevalent. One thing is certain, that some kinds are more subject than others to the disease—the old variety known as "Forty-folds" being this season (1879) particularly subject to curl in the southern counties.

120. Potato Disease.—Potato disease, or potato murrain, a moist gangrene, which first became prevalent about 1845, is the result of the growth of a peculiar kind of fungus.

It seems to be induced by an excessive degree of cold and wet at that period of closing growth, when all bulbs and tubers require an increased degree of dryness and warmth. If the hyacinth, or tulip, or dahlia be submitted to similar unfavourable conditions, its bulbs or tubers similarly decay.

---

* Parenchyma (Gr. para, beside, and chymos, juice) the cellular tissues of vegetables.

In 1845 the months of July and August were unusually wet and cold, and early in August were sharp morning frosts. The potato stems immediately began to decay, but the weather continuing wet, instead of their decay being dry, and attended with the usual phenomena of their reduction to woody fibre, the putrefaction was moist, and the smell attendant upon it precisely that evolved during the decay of dead potato haulm partly under water. The stems decayed, whilst the fibres connecting the tubers with them were fresh and juicy; the diseased sap, being absorbed by their still immature and unusually juicy tubers, imparted to them the gangrene, the infection first being apparent at the end nearest the connecting fibre, gradually spreading throughout the skin of the tuber, rendering it brown, like a decayed apple, and lastly causing the death of its interior portion. Previously to the final decay the increased specific gravity of the potato was remarkable, amounting to one-third more than that of a healthy tuber—an increase caused by its greater amount of water. The potato fungus is usualy classed with a small family of parasitic fungi, which, since 1863, has been known as *Peronsporeæ*. The phenomena connected with its growth are tolerably uniform. According to Dr. Voelcker, in his "Researches into the Nature of the Potato-Fungus," all are typical parasites in living plants containing chlorophyll (the green-colouring matter in the leaves of plants).

"Their complete development is dependent on their finding the living organism, with its chemical and physical properties, which will afford it a suitable host; and most species are so restricted in this respect that they can only grow in certain species, or groups of species of plants, but not in others—a condition which holds good for parasites generally."

121. Canker in Fruit Trees.—This term is usually applied to those cases in which a greater or less portion

of a tree loses its vitality from some latent disease, and which, as a rule, ultimately detroys the parent stock. In cherry and other stone-fruit trees the disease is generally called "gumming," from the peculiar character which it assumes.

The unhealthy trees affected with canker exhibit branches which wither and die without any apparent cause. If the dead portions are removed, the disease spreads itself to the adjoining parts, and the tree in the course of time becomes wholly affected and finally dies.

Certain varieties are far more subject to the disease than others—so much so, in fact, that their successful cultivation for any length of time becomes impossible in unfavourable localities. Several causes have been assigned to account for the disease, but it is probably caused by lowness of temperature, accompanied by wet either above or below the soil.

As the cells of plants are to an extent independent of each other, the causes which affect one cell, or contiguous sets of cells, may not influence the rest. The health of this isolated part is deranged, disease is set up, and ultimately decomposition takes place. By a well-known law, decomposed matter existing in contact with healthy matter rapidly communicates disease, and in this way the adjacent parts become sluggish, and finally the whole branch passes into a state of decay.

122. Woods and Plantations.—Woods in this country are generally understood to mean a collection of growing timber of spontaneous growth.

Plantations are grounds planted by man for the purpose of growing useful timber, or for ornamental effect.

The uses of forests are numerous and important; not only is timber absolutely necessary for every description of architecture and rural occupation, but growing trees improve the climate, and are supposed to exercise an electric influence on the atmosphere.

However this may be, the quantity of carbon absorbed and the chemical change induced by the surface of leaves exposed in a forest cannot fail to affect the atmosphere, and the removal of forests alters the equilibrium obtained through successive centuries. By its absorbent surface a forest withdraws from the air much more carbonic acid than meadows or cultivated fields and exhales much more oxygen.

As conductors of heat, trees prevent radiation both of heat and moisture; they check the movements of winds and sensibly diminish the cold. The absence of wood is a great cause of the aridity of the climate of Spain, and many districts in France have suffered from clearing; while instances of the beneficial influence of planting and restoring woods are not wanting in Scotland, Southern France, Italy, Egypt, and other parts. Forests also affect the supply of water to springs, for they protect the fallen rain from evaporation, and give it time to sink deep into the earth.

The following extract from the writings of Professor Ansted can hardly be considered an overdrawn description:—

"The inevitable result of the clearing away of forests over a large tract of country must be, that during one season the earth parts more rapidly than before with its heat, by radiation; at another, it receives an undue supply from direct exposure to the sun. The soil is alternately parched in summer and chilled in winter. The precipitation of rain becomes less regular. The surface becomes more and more exhausted of the elements of a good soil. The uplands become rapidly removed by degradation; the lowlands are injured by torrents covering the soil with rocky fragments; the channels of the rivers are choked, and their mouths interrupted by bars. A few exceptions to this, and the fact that in certain districts the climate does not seem to have been seriously deteriorated

within the historic period, do not prevent the general conclusions here given from being correct."

Of the native trees of this country, there are only about twelve genera and thirty species which attain the height and size of timber trees; and of these the Scotch fir, the holly, and the yew are the only evergreens.

It is generally supposed that many of our timber trees, together with several of our cultivated fruits and vegetables, were brought to Britain by the Romans or the monks of the Middle Ages; but it was during the sixteenth century that plantations began to be extensively formed for timber and ornamental purposes, and at this time the common spruce fir, stone pine, evergreen cypress, sweet bay, walnut, pineaster, laburnum, evergreen oak, arbor-vitæ, and a number of smaller trees and shrubs were known to be introduced. In the seventeenth century many exotics were introduced, chiefly from America; and Botanical Gardens becoming established in different parts greatly facilitated the introduction of hardy trees. On the authority of the *Hortus Kewensis* (Dr. Hooker) the most important foreign trees introduced in this century were the cedar, silver fir, larch, horse chestnut, acacia, scarlet maple, Norway maple, American plane, scarlet oak, weeping willow, balsam poplar, Balm of Gilead fir, cork-tree, the black and white American spruce firs, with many others of dwarfer habit.

In the eighteenth century nearly 500 foreign plants were introduced, but about three-fourths were shrubs, and more than half the number were natives of North America. The timber trees consisted chiefly of oaks, pines, poplars, maples, and thorns. At this time nurseries for every plant in demand were established, and the taste for planting foreign trees rapidly spread amongst the great English landowners. Early in this century, the spirit of planting on a large scale for profit began

to awaken in Scotland, and through the examples of the Duke of Athole, the Earl of Haddington, and other Scotch noblemen, planting became very general throughout that country.

During the present century extensive and very valuable additions have been made both to our list of shrubs and timber trees, particularly in the coniferæ or cone-bearing tribe. These have mostly been brought from North Amercia and the Himalayan Mountains.

As living objects, trees have always been considered the grandest which the earth produces, and the origin of this respect for trees appears to be coeval with the formation of the human mind. From the time of the Creation, when our first parents were placed in that garden where the Lord God made "*to grow every tree that is pleasant to the sight and good for food; the Tree of Life also, in the midst of the garden, and the Tree of Knowledge of good and evil,*" to the days of the patriarchs, the expression of feeling, as evinced in Biblical language, is but an expression of the current feelings of the present day in reference to such subjects. Thus, "*The field and the cave which was therein, and all the trees thàt were in the field, that were in all the borders round about, were made sure unto Abraham for a possession.*"

123. Conditions Regulating the Selection and Luxuriant Growth of Timber and Underwood.—(1.) *A Correct Appropriation of Certain Trees to Particular Soils and Situations.*—A loose, deep earth will grow trees of any description; a poor, dry, gravelly, or a chalky formation will best suit the beech, birch, and the pines. A clay soil, or a deep clayey gravel, is best suited to the oak, and the most profitable tree to plant with it is the larch, which feeds chiefly on the surface, while the oak sinks its roots down into the subsoil. Ash and Scotch elm are valuable timber trees, which require a good, deep, loose soil.

Fast-growing, soft-wooded trees should be placed in

moist situations, or near water. This class includes the alder, willow, poplar, lime, and horse chestnut.

Cone-bearing, or resinous trees, delight in cold, elevated districts with a poor thin soil.

Broad-leaved timber trees should be placed on good lands. The principal are the ash, beech, birch, elm, hornbeam, locust, oak, plane, Spanish chestnut, sycamore, and walnut.

(2.) *The relative growth of trees* should be considered, so as to afford sufficient space for their development.

(3.) *Nursing* when young by the quick growth of other plants prevents the more valuable sorts from getting into a bushy form. The inferior kinds are cleared as required.

(4.) *Pruning*, early and judiciously performed, will increase quality, dimensions, and ultimate value.

(5.) *Protection* by fencing, and the usual care and superintendence, are necessary to their continuous growth. Thinning will ensure "the survival of the fittest."

124. The Durability of Timber, how Increased and how Decreased.—This depends on the growth, time of felling, and general management.

One of the most important objects to be kept in view in timber management, whatever mode of pruning is adopted, is to cause timber to be rapidly formed. This is little known, and, indeed, is contrary to the experience of many woodmen. Most people believe that the slowest grown timber is the best, and some writers on forestry follow the same line of assertion.

English oak grows sometimes an inch in a year.

* All plants consist of one or other of two substances—the one cellular, the other fibro-vascular. The former is composed of roundish cells, the latter of long tubes; both are termed tissue by physiologists. The cellular tissue is brittle, with the texture of a mushroom or the

---

* Extracts from "The Theory and Practice of Horticulture," by John Lindley, F.R.S.

pith of elder: fibro-vascular tissue is tough and strong, like hemp and flax. Timber consists of these two tissues intermixed, and when it grows *slowly* it is more cellular than fibro-vascular. There is never expansion of the fibro-vascular parts; all that happens is that *the aggregate number of the latter is increased.*

Thus, suppose a stick an inch in diameter to contain 500 tubes: if it be made to grow twice as fast, it will not expand those tubes, but it will add 500 more to its original number in the same period. Esculent herbs and woody plants differ thus—the former is composed of cellular substance, and the latter of fibro-vascular. Willows, poplars, &c., are not soft, because they grow fast, for they are just as weak when they grow slowly, and weaker.

Their want of strength and durability arises from their inability to consolidate their tissues by depositing within them matter of lignification. The system of spring felling is without doubt highly injurious in the case of deciduous trees, for the wood is then full of sap, which not only makes the process of seasoning more tedious, but when dried it affords nutrition for the growth of the germs of fungi, and this causes dry rot. It is extremely doubtful whether the value of the bark compensates for the injury done to the timber from this practice.

CHAPTER XX.

125. Farm Buildings.—As the buildings of a farm are intended for the transaction of many of its most important operations, the perfect adaptability of each to its separate purpose, to the farm and to each other, will at once appear to be of the highest importance as a means of economy both of time and labour.

The site of the farm homestead should be selected with a due regard to aspect, dryness, drainage, water supply, shelter, and free air, as a means conducive to the healthy condition of both man and beast, and consequently to the profit of the farmer.

As regards their extent, they should be sufficient and complete; designed to meet the special requirements of the farm; and well built of good materials to ensure durability. If too limited, the necessary accommodation is inconveniently restricted, and if too extensive a larger expenditure is required for repairs, or the useless buildings fall into ruin from neglect.

With regard to aspect there is a certain point in every locality from which, owing to local peculiarities, storms are more frequent than from any other. In the arrangement of the buildings it is obvious that such an aspect should be selected as will afford the best shelter under the circumstances. Independently of this, a south-east aspect in this country is usually found not only to be most sheltered from high winds and driving rains, but to be most open to the genial influences of sun, light, and air.

Dryness may be secured by a thorough drainage, and may be classed among the improvable conditions of a site. At the same time a naturally dry soil will always be found more suitable for the erection of buildings than one which is retentive of moisture: gravel and clay are the two extremes.

Drainage will improve the condition of even a bad site; and though the relative position of the various buildings may be in some instances partly regulated by the natural slope of the surface, the system of drainage on the premises should be such as to readily ensure that all liquids from the stables, cattle sheds, &c., should be carefully secured and utilised—neither wasted nor washed away.

A proper supply of water is of such primary impor-

tance that when no stream or brook is available, its existence should be established either by sinking or boring, as an essential preliminary to the choice of a site; for whatever the sum of the advantages of a site may otherwise be, the want of a proper water supply renders them entirely unavailable.

Shelter, as already stated, may be partially secured by a judicious arrangement of the buildings. Its beneficial effects may also be enhanced by planting belts of timber in the direction of prevailing winds, and by taking advantage of any natural features.

With reference to the farmhouse itself, regard must be had to the comfort and convenience of the occupants, as well as to the health and comfort of the stock. Whatever the position of the house, it should be so placed as to ensure ready communication with the rest of the buildings, especially in a dairy-farm, where much of the necessary labour is carried on by the domestic servants. It is often advisable in small establishments, or in exposed situations, that the house should be contiguous to the buildings for the sake of mutual shelter; but every case should be determined on its own merits, and, other things being equal, the most pleasant situation which the neighbourhood affords should be the site selected.

In placing the buildings, it is desirable that they be as near the centre of the cultivated ground as possible, and on a gently sloping surface rather than on the higher grounds of the farm, as this offers greater facilities for conveying the crops to the homestead. This central position, however, has often to be sacrificed to obtain a proper water supply for the homestead, which is often utilised as a motive power for driving machinery.

126. System of Arrangement and General Plan of Construction according to the Description of Farm and the Peculiarities of the District.—In the arrangement of the buildings there are some *general principles* of construction common to every class of farm. The

main object is to have the house and offices so arranged as to save all the time and labour possible, and to enable the farmer to carry on his business with the fewest number of servants, by which the advantage of order, industry, and economy are secured; for it should always be borne in mind that it is more important to save time in comparatively insignificant operations of frequent occurrence than in larger matters which are not often repeated.

Another important principle is to group together all buildings or apartments used for like purposes. Thus the yards and houses for particular descriptions of stock should be placed together; the stables should be kept by themselves; the dairy cows apart from the feeding stock; the pigs, poultry, and young stock each in their proper locality, and yet the arrangement of the various stalls and houses should admit of the *mixing* of the various manures in a common fold-yard where the work can be conveniently carried out.

It is convenient to have a working yard or court, round which are arranged sheds for the various wheel-carriages of the farm; root houses; places for storing and preparing food; and a place where tools and implements can be kept and repairs conveniently executed.

In addition to this, the highest buildings should be placed to afford shelter from prevailing winds, and yet not to intercept the rays of the sun from other yards and buildings. A common entrance secures the safety of the yards at night, which in some situations, as in the neighbourhood of towns, is a necessary precaution.

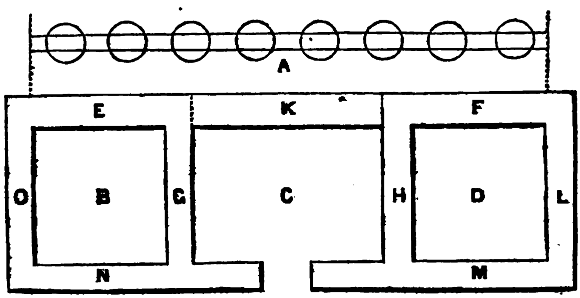
Formerly the buildings on a farm were commonly arranged in the form of a square, with a common yard in the centre, into which all litter was thrown and the stock huddled together, with an utter disregard to the principles of rural economy, now, happily, so much better understood.

As better ideas prevailed, the advantages of more extended accommodation became apparent, as it was found

that increased shelter was invariably followed by improvement of the stock. At first, sheds were placed at one end only, but gradually began to assume the form of a long parallelogram, and it is now admitted that the most convenient form of arrangement is that of a long rectangle with the closed side to the north or north-west, and the open side facing the south or south-east. The idea of shelter is now carried so far, that in many modern homesteads, where money is no object, the whole of the yards are covered in, thus adding to the comforts of the stock, and the quality of the manure produced.

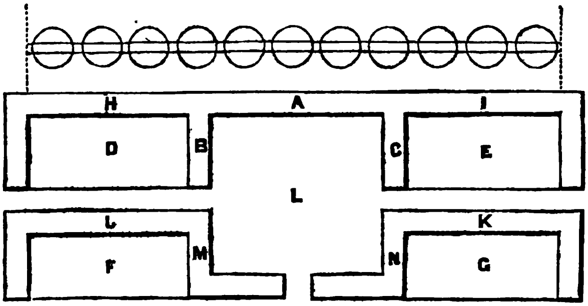
In carrying out the principles of arrangement here described, some little variety may be obtained, which is regulated by the position of the barns, K, as illustrated in the following diagrams:—

(Fig. 17.)



In Fig. 17, A is the stackyard, and the spaces B, D, and C, the cattle and working yards respectively. The buildings G, H, in the immediate vicinity of the working court, would be used for the accommodation of the carriages and implements and the apparatus for preparing food. The buildings M and N would be used for such animals as require but little straw, and O and L for storehouses, &c.

(Fig. 18.)



In Fig. 18 the straw-barn B is turned at right angles to the dressing-barn A, and connected with the latter is C, the granary and implement house. In this case D, E, F, and G will be the cattle yards, and H, I, J, K their respective shelter sheds; L is the working court, M the stables, N the store and house for preparing food, while the remote ranges will serve the same purpose as in Fig. 17.

(Fig. 19.)

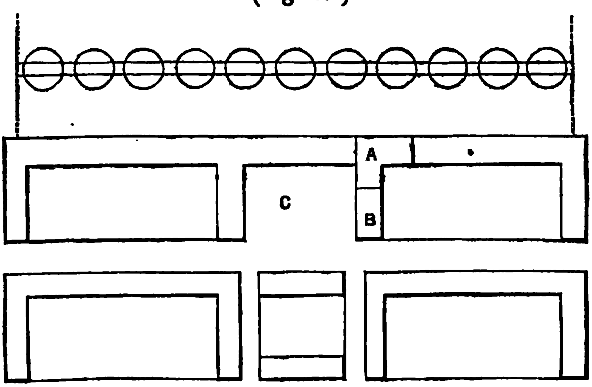


Fig. 19 shows a very useful arrangement whereby the altered position of the straw-barn A gives larger accommodation for stock at a very small expense, as the yards are mostly enclosed by the walls of the buildings and the straw is stored near the place of consumption. The house B, for preparing the food, is in communication with the machinery of the barn, so that chaff-cutting, grinding and bruising corn, &c., can be done with the least possible expenditure of time and labour. The working court C is here, too, in its best possible place, and the other buildings will be used for the same purposes as before mentioned.

Other arrangments may be adopted to suit the peculiarities of the site, but most of them are based on the relative positions of the straw-barn, and the sheds and houses where the straw is to be consumed. Whatever may be the nature of the obstacles which prevent these important principles from being carried out in their entirety—and slight variations must be made to suit the peculiarities of every case—a judicious designer will make such arrangements as are best calculated to secure the maximum of advantage and the minimum of evil; he will know what to forego and what to secure.

SCIENCE SYLLABUS, SUB. XXIV.

INDEX TO PARAGRAPHS.

NOTE.—The headings of paragraphs specially referring to the Elementary Stage of the Syllabus are printed in italics.

CHAPTER I.

1. *Soils.* 2. *The different kinds of soils; variations in their composition, texture, and condition.* 3. Classification of soils as determined by physical conditions and chemical composition. 4. Active and dormant constituents of soils. 5. Conditions regulating the conversion from the dormant state into an active condition available for vegetation. 6. Chemical and physical conditions regulating the barrenness and fertility of soils. 7. Mechanical condition of soil in relation to the growth of seed. 8. Power of the soil to hold manure; how to be assisted artificially. 9. Essential differences in the cultivation of light and heavy soils. 10. Influence of climate on the productive powers of the soil.

CHAPTER II.

11. *Substances found in plants.* 12. *Source from which these are obtained.* 13. *Exhaustion of the land.* 14. *The essential differences between good and poor land.* 15. *The necessity for manure.* 16. *The production and waste of farmyard manure.* 17. Conditions regulating the production, management, and application of farmyard manure. 18. Variations in quality, and consequent results. 19. Under what conditions is green manuring desirable.

CHAPTER III.

20. *The use of artificial manures; how manufactured, and the reasons for their employment.* 21. Conditions regulating the use of artificial manures. 22. Bones as a manure, and how they are most economically employed. 23. Substitutes for bone.

CHAPTER IV.

24. *Lime, marl, chalk as manures.* 25. Action of lime as a fertiliser. 26. Control of its causticity according to required results. 27. Action of the several phosphates of lime as fertilisers. 28. Conditions rendering their use so generally necessary. 29. Control of their soluble condition. 30. How to avoid their waste in the soil. 31. On what soils most economically used. 32. Their action on seeds and young plants. 33. Special action of nitrates and ammoniacal manures upon corn crops, roots, and grass. 34. Means of controlling the soluble condition of ammoniacal manures. 35. Conditions under which nitrates can and cannot be substituted for ammoniacal manures. 36. The special action of salt when used alone and also in conjunction with other manures. 37. Manufacturing wastes valuable as manure. 38. Adulteration of manure.

CHAPTER V.

39. Combination of manures of different character, so as to establish an equilibrium of action. 40. Proper times of application. 41. Favourable and unfavourable action upon different stages of growth. 42. Desirability of providing proper supply for final stages of growth. 43. Proper relation between natural and artificial manures, when substitutes and when supplementary. 44. General principles regulating the selection of manures. 45. Manures which impoverish the land. 46. *Tillage operations.* 47. *Reasons for ploughing and mowing land by implements.* 48. *Any changes produced in the soil, and their influence on the growth of crops.* 49. *Drainage of the land, when necessary, and its mode of action.*

CHAPTER VI.

50. *Crops grown on various kinds of soil.* 51. *Succession or rotation of crops; how selected and arranged.* 52. Conditions regulating the selection and rotation of crops. 53. Relative powers of exhausting or improving land. 54. Chemical composition of different crops? 55. *Good courses of cropping. Bad*

courses of cropping. 56. Period of highest nutritive value. 57. Chemical changes in the ripening of grain, roots, and fodder crops. 58. Necessity for this action. 59. Influence of climate on the perfection of growth attainable.

CHAPTER VII.

60. Combined influence of soil and climate upon the system of husbandry, upon the malting qualities of barley, the nutritive quality of the flour of wheat and oats, the feeding power of roots, and the various kinds of straw.

CHAPTER VIII.

61. Conditions regulating the vital power of seeds, their character and quality. 62. Pedigree influence. 63. Effect of age of seed upon the form and character of its produce, its rapidity of growth, and liability to disease. 64. Change of seed, why necessary. 65. Adulteration of seed.

CHAPTER IX.

66. *Live stock. Best kinds of stock for various farms. The economy of good stock management. Ordinary rules for preservation of health.* 67. Principles regulating the breeding of stock. The reproductive powers of animals, how strengthened and how rendered abortive. 68. Pedigree influences, how intensified and how reduced. Good and bad qualities, how controlled. 69. Means for maintaining constitutional vigour. 70. Fixity of type, how established in new breeds. 71. Difference between breeding in-and-in, and breeding in the line. 72. Results from each system. 73. Causes of barrenness in male and female. 74. Loss of size in pedigree stock.

CHAPTER X.

75. On what is the special aptitude of various breeds for different conditions of soil and climate dependent? 76. Influence of change of soil and climate on the stability of a breed. 77. Principles of acclimatisation. 78. *Special requirements for making land either a good dairy farm or a good sheep farm, or good grazing land.* 79. Principles regulating special pecu-

liarities, such as early maturity, rapid production of flesh and fat, growth of wool, and production of milk.

CHAPTER XI.

80. Influence of breed, climate, soil, food, and shelter upon the production of wool, as affecting its fineness of fibre, its even character, its felting power, and the quantity produced.

CHAPTER XII.

81. General conditions controlling the production of milk, the quantity and duration of the flow, and the quality of the milk. 82. How to increase the oil of milk for butter dairies, and also the curd of milk when cheese is required. 83. Action of heat, as in the process of scalding milk. 84. Influence of food and exercise upon the yield of butter and cheese. 85. Peculiar influence of irrigated or sewage grass upon dairy produce.

CHAPTER XIII.

86. *Food. Chemical matters present in various kinds of food—in milk, green food, hay and corn, &c., &c.* 87. *The different materials necessary for the growth of the body.* 88. *Maintenance of heat.* 89. *Process of fattening animals.* 90. Constituents of various kinds of food, and proper classification. 91. Conditions regulating the increase of flesh and fat obtainable from any given food, or mixture of food. Influence of shelter as a means of economising food. 92. Increase of feeding power by proper preparation of food. 93. Conditions regulating the use of manufactured feeding materials and condiments. 94. Advantages resulting from the purchase of food as a means of enriching a farm. 95. Good and bad systems of feeding stock.

CHAPTER XIV.

96. Malting of barley; the chemical changes produced. 97. Composition of barley in its influence upon the quality of malt. 98. Its action as a feeding material.

CHAPTER XV.

99. Relative value of natural and artificial grasses. 100. Conditions regulating the fertility of grass land. 101. Agencies

which cause loss of plant. 102. Change in the herbage under the action of manure. 103. Principles upon which haymaking should be regulated so as to preserve feeding properties.

CHAPTER XVI.

104. Drainage of land. 105. Chemical and physical influences exerted upon the soil and subsoil. 106. Respective actions of water in motion and when stagnant.

CHAPTER XVII.

107. Irrigation. 108. Various qualities of water employed. 109. Mode of action. 110. Duration of flow. 111. Relative advantages of the various systems for distributing the water. 112. Quality of herbage. 113. Relative qualities of raw and clarified sewage. General principles regulating their use. The imperfect character of sewage as a manure. 114. Quality of crops grown under its use.

CHAPTER XVIII.

115. Orchards and fruit grounds. 116. Influence of soil and climate upon the varieties which can be successfully grown. 117. Essential conditions of healthy growth and production of fruit. 118. Chemical conditions which regulate the selection and ripening of fruit for the manufacture of cider and perry, the fermentation of the juice, and the preservation of its quality.

CHAPTER XIX.

119. Diseased condition of crops. 120. Bunt, or smut-ball mildew, and blight in corn crops. 121. Finger and toe, clubbing and curl in root crops and cabbages. 122. Potato disease. 123. Canker in fruit-trees. 124. Woods and plantations. 125. Conditions regulating the selection and luxuriant growth of timber and underwood. 126. The durability of timber, how increased and how decreased.

CHAPTER XX.

127. Farm buildings. 128. System of arrangement and general plan of construction according to the description of farm and the peculiarities of the district.

EXAMINATION QUESTIONS

SET BY THE

SCIENCE AND ART DEPARTMENT (1876).

*** *The numbers refer to the paragraphs of the text in which an answer to the question may be found.*

FIRST STAGE, OR ELEMENTARY EXAMINATION.

1. Of what materials are soils generally composed, and what are the chief points of difference between the composition of a good soil and a bad soil? (2, 14.)

2. Do plants obtain all their nourishment from the soil? If not, state what is obtained from any other source. (12.)

3. Why are some crops grown more perfectly on some soils than upon others? Give examples. (11, 50.)

4. What are the materials in vegetables which are the most useful for the production of flesh, bone, and fat in the animals using them as food? (87—89.)

5. Give examples of the manner in which you would supply any materials known to be deficient in the soil. (20, 21.)

6. Explain the general action of lime as a manure. (24.)

7. On what principles would you regulate the succession of rotation of crops? (51.)

8. How do tillage operations—such as ploughing, harrowing, rolling, &c.—increase the fertility of the soil? (46—48.)

9. Are there—and if so, what—advantages to be gained by growing "root crops" instead of leaving the land in "bare fallow"? (12.)

10. Does any injury arise to a growing crop by reason of the

land not being properly drained? If so, explain the cause of such injury. (49.)

11. What general rules ought to be observed in the selection and use of food for cattle when fattening? (89.)

12. What is the difference between the shape and touch of a well-bred animal, and one of the unimproved or common breed; and how is it the one is more valuable to a farmer than the other? (66, 79.)

SECOND STAGE, OR ADVANCED EXAMINATION (1876).

21. How would you classify soils by the chemical constituents they contain, and by their physical conditions; and how do these influence their agricultural value? (3.)

22. Describe the materials necessary for the growth of cultivated crops, their sources of supply, and the condition in which plants receive them. (11, 12.)

23. Explain the influence of soil and climate upon the degree of perfection obtainable in a plant's growth. (48, 59.)

24. Explain the principles regulating the selection and the economical use of artificial manures. (20, 21.)

25. In returning to the soil the mineral matter removed from it by the bones of animals reared upon it, what materials are used for the purpose, how are they prepared for use, and in what chemical condition is it desirable to apply them to the soil? (22.)

26. How can you regulate the fermentation of farmyard manure; and under what circumstances should it be more or less fermented before it is applied to the land? (17.)

27. Give a course of cropping suitable for heavy land, and another course for light land; show the relative advantages of each course, and give your reasons for considering them suitable for these soils. (50—52, 55.)

28. Trace the chemical and physical changes which arise in the disintegration of a rock into soil; show how these changes arise, and the manner in which cultivation renders the soil more available for vegetable growth. (1—6.)

29. Describe the practice of "bare-fallowing" land; explain the reasons which have led to growth of root crops instead of bare fallows, and indicate the advantages arising from this change of system. (12, 22, 55, 59.)

30. Explain the advantages arising from land-drainage, and the consequent changes effected in the chemical composition of the soil and in its physical condition. (49, 105.)

31. How would you vary the general management and the food of cattle according as they may be young growing animals, breeding stock, or fattening for sale? Give your reasons for such variation. (87—92.)

32. State the advantages arising from keeping well-bred stock, the difficulties which specially accompany such stock, and the best means for preventing or overcoming these difficulties. (66—74.)

HONOURS EXAMINATION (1876).

41. How would the course of husbandry most desirable for a farm be influenced by the character of its soil and clime?

42. Describe the circumstances under which water may become injurious to the fertility of the land, and how it may be employed to increase its productiveness; giving an explanation of the principles involved.

43. Trace the changes which vegetable matter undergoes from its original condition in the plant until it forms part of the structure of the living animal.

44. What changes take place in the malting of barley, what are the relative qualities of malt and barley as food, and on what principles should the use of malt be regulated?

45. How does a good pedigree influence the profit of the producer of meat, and what are the dangers to be avoided?

46. What are the relative advantages of enriching the land by the direct application of artificial manure, and by the production of additional manure by the use of artificial or other food?

47. Can artificial manures be supplied so as to impoverish the land? If so, how would you avoid such injurious results?

48. What circumstances influence the duration, the quantity, and the quality of milk of a breeding animal; and how may these results be controlled?

FIRST STAGE, OR ELEMENTARY EXAMINATION (1877).

1. Mention the various descriptions of soils, and the manner in which you distinguish them from each other. (2.)

2. Why do soils differ in their productive powers? (1—3.)

3. What do you understand by a rotation of crops, and why is this necessary? (51.)

4. Why is the use of farmyard manure so generally valuable in increasing our various crops? (16—18.)

5. Do you know of any other manures which are used upon the land, and the reason for selecting any of them for particular crops? (20.)

6. How does the drainage of land increase its fertility? (49.)

7. Give the general composition of milk, and state why it is a good food. (86.)

8. Compare the composition of milk with that of other kinds of food, and show the advantages of each. (86.)

9. What rules would you follow in selecting the best food for fattening animals? (87—89.)

10. How does lime act as a manure? (25.)

11. What is the difference between the active and dormant materials in a soil? (4.)

12. How can they be changed from one condition to the other? (5.)

SECOND STAGE. OR ADVANCED EXAMINATION (1877).

21. What circumstances and conditions regulate the fertility and barrenness of soils, and how may the latter be overcome? (6.)

22. Explain the manner in which tillage operations render soils more productive. (46—48.)

23. Take any one of our ordinary farm crops, and show the conditions most favourable for its perfect growth. (52.)

24. How would you regulate the treatment of farmyard manure, so as to secure it in the best condition for use upon the land? (16—18.)

25. Explain the chemical changes taking place in the preparation of farmyard manure for the land. (16—18.)

26. What rules would regulate you in the choice of artificial manures for special crops? Give instances showing the application of such rules. (21.)

27. Show the conditions which should regulate the rotation of crops, and illustrate the same by examples of good and bad courses of cropping. (52—55.)

28. State the circumstances which should regulate the choice of food for stock, and the manner in which its economical use may be best secured. (90—98.)

29. How is the production of wool influenced by food and general management? State what conditions favour its growth and quality. (80.)

30. Explain the influence of drainage and irrigation upon the fertility of the soil, and any necessary connection between the two agencies. (104—106.)

31. What are the advantages gained by a careful control of pedigree influence in the case of cattle, sheep, and pigs respectively? (66—79.)

32. What are the conditions which favour the production of meadow hay of high nutritive character? (103.)

HONOURS EXAMINATION (1877).

41. On what principles is our practice based for securing early maturity in stock? Show how the quality and quantity of the meat produced are influenced thereby.

42. How do you explain the tendency which exists in high-bred stock to a loss of constitutional strength, and how is this best held under control?

43. State the conditions of growth most favourable for the production of roots and corn of the most nutritive character Give examples illustrating their successful application.

44. Point out errors of practice occasionally observed in the irrigation of land, and state your reasons for objecting to such mode of procedure.

45. What are the relative advantages of enriching the land by the use of artificial food and artificial manures respectively, and how far can the use of the former advantageously supersede the use of the latter?

46. Show the influence exerted upon the quality and character of a crop by a judicious selection of suitable seed, and the means whereby that influence is best maintained.

47. Describe the variations observable in the quality of wool, and the circumstances which influence its successful growth.

48. Give an example of the advantages arising from the application of science to ordinary farm practice, and state the principles involved therein.

FIRST STAGE, OR ELEMENTARY EXAMINATION (1878).

1. What food do plants require for their growth, and where do they obtain their supplies from? (11, 12.)

2. How do soils become exhausted and unable to produce good corn crops? (13.)

3. Why do we apply farmyard manure to the land, and how should it be used? (15, 16.)

4. Why do farmers plough, harrow, and roll the land, and bring it into fine condition? (46, 47.)

5. How are soils formed? (1.)

6. What do you know about the action of lime as a manure? How is it used, and what good does it do to the land? (24.)

7. Why do we drain land, and how is land improved by draining? (49.)

8. What are the principal substances found in the different kinds of foods used for farm stock, and what is the use of each of these substances? (86, 87.)

9. Why is food made more useful for farm stock by protecting them from exposure to cold and wet? (88, 89.)

10. Why is it desirable to grow crops in regular succession instead of growing the same crop year after year? (51.)

11. Do sheep, eating a growing crop, return to the land in their manure all that the crop took from the land? If not, state how any loss has arisen. (87, 88.)

12. What are artificial manures, and why do we use them upon the land? (20, 21.)

SECOND STAGE, OR ADVANCED EXAMINATION (1878).

21. Why do soils differ in their powers of producing good corn crops? (50—53.)

22. What advantages do we gain by ploughing land so as to expose it to the cold and rain of the winter months? (5.)

23. How do you classify and describe our various soils according to their mechanical condition and chemical composition? (3.)

24. What duties have to be performed in the soil by manures, and why is it necessary to use the various kinds of manures commonly employed? (13.)

25. What chèap materials are used to take the place of bones as a manure, and how are these materials most advantageously used? (23.)

26. What substances must be present in a perfect food? Give an instance of a perfect food, and also of food which is unable to support life. (86, 87.)

27. What rules should regulate you in the selection and use of food for cattle, when growing, milking, and fattening respectively? (86—93)

28. Why are some animals more economical producers of meat than others? (79.)

29. How should the fermentation of farmyard manure be regulated so as to avoid any loss of its fertilising matter; and what difference would you make in the fermentation when the manure is going to be used for a sandy loam, or for a clay loam, or for spreading upon clovers? (8, 9, 16, 17, 52.)

30. Is the continuous growth of corn crops inconsistent with

the general principles regulating the rotation of crops? Explain the conditions which influence the result. (52.)

31. Why do some soils retain for the use of plants the manures added to the soil, whilst other soils allow them to be washed away? Give instances of each, and state any means adopted for correcting this bad character. (8.)

32. State on what principle you would select manures suitable for producing grass of high feeding character. (78, 99, 100.)

HONOURS EXAMINATION (1878).

41. How may the fertilising matter of farmyard manure be rendered slowly available for a corn crop upon light lands (such as sands and sandy loams) which possess little power of retaining manure? Describe the ordinary course of practice adopted to attain this object.

42. What phosphatic and nitrogenous artificial manures can be employed upon soils which possess little power of retaining manure, so as to secure a steady supply of each throughout the plant's growth?

43. What are the usual causes of mildew upon root crops? Indicate some errors of practice which favour its production.

44. Why is the weight of meat produced from a given quantity of food influenced by other circumstances than the feeding powers of the animal, and the quality of the food given?

45. What are the differences in form which distinguish a good feeding animal from a good milker, and how is the variation in the external form associated with the internal organism of the animal?

46. Why do some stock lose constitutional vigour? How may this loss of strength be held in check?

47. In what respects do the pedigree influences observed in seeds correspond with those in live stock, and wherein do they differ?

48. What circumstances influence the strength and even character of the fibre of wool, and also increase the weight of

fleece produced? Give instances of a want of soundness in the stape arising from bad farm management.

49. What principles would regulate you in the construction of a homestead for a clay farm, where roots are to be consumed by cattle bred upon the farm?

50. Give an example of the advantages arising from the application of science to ordinary farm practice, and state the principles involved therein.

FIRST STAGE, OR ELEMENTARY EXAMINATION (1879).

1. What is the difference between a sandy soil, a loam, and a clay soil? (3.)

2. What are the principal substances found in a soil, and which of these do plants require? (1, 2.)

3. Why do we grow crops in rotation, instead of continuing to grow the same crop upon the same ground, year after year? (50, 51.)

4. What is the composition of milk? State why it is such very good food. (86.)

5. Give a good course of cropping for a rich loam soil, and a bad course of cropping for a sandy soil. State your reasons in each case. (55.)

6. Of what does the inorganic matter of plants consist? How does the plant get it, and why is it called the ashes of a plant? (1—3.)

7. What are marls, and upon what does their value depend? (24.)

8. How does a soil lose its phosphates? What becomes of the phosphates removed from the land, and how may they be restored to the land? (13, 20.)

9. As the soil very largely consists of hard solid matter, how is it that plants are able to feed upon it? (4.)

10. Why are soils improved by exposure to rough and cold weather in the winter? (4, 48.)

11. How is it that cattle and horses are warm, and by what means is this warmth kept up? (88.)

12. Why do some animals fatten better than others when using equal supplies of food? (66, 89.)

SECOND STAGE, OR ADVANCED EXAMINATION (1879).

1. In what respect does the food of an animal differ from the food required by a vegetable? (11, 86—88.)

2. What is meant by saying that "land is sick of a crop"? Give an example, and say how it may be remedied. (13, 15, 86.)

3. What are the special advantages arising from autumn cultivation, and how do you explain its value? (46—48.)

4. Can a soil contain all the food necessary for producing good crops, and still be unable to give it to plants as food? If so, why is this, and how may it be overcome? (3, 5.)

5. Describe how lime and farmyard manure may be used for a crop with the best results, and also how their fertilising powers may be injured by an improper mode of application. (26.)

6. A cubic foot of sand weighs about 110 lbs., and a cubic foot of clay weighs about 80 lbs.; why do we call sands light soils, and why do we call clays heavy soils? State what are the causes of the difference. (8.)

7. How do you account for the variations observed in the ashes of plants? (11, 12.)

8. How does drainage of the land increase the quantity of plant-food ready for use in a soil? (49, 104, 105.)

9. What are "Reduced Superphosphates," and what is their action in the soil? (20.)

10. How are lands fertilised by irrigation, and how should the supply of water be regulated? (107—111.)

11. What changes does the blood undergo in its passage through the body? (88—92.)

12. Describe the changes which food undergoes in its digestion by a bullock and a horse, pointing out any differences. (91.)

HONOURS EXAMINATION (1879).

1. In what way does climate influence the system of farming, and also the quality of meat and corn produced? Give instances.

2. Trace the various changes which take place in a plant's growth during the time its supplies are drawn from the soil and the air, and show the disadvantages arising from the use of food which has not been fully ripened.

3. How does the condition and use of fertilisers, and the character of the seed, render some root crops less able to withstand the frost; and how may roots of the highest feeding character be secured?

4. How do soils retain manure, and how should light sands be treated to increase this power?

5. Describe the formation of nitre in earth, and show how soils may thus be economically enriched.

6. Describe fully the process of germination. Show how this is controlled for the production of malt, and state the conditions which regulate the quality of malt.

7. How does the blood of an animal receive fresh supplies of nutriment; how is it removed from the blood, and what determines its new form in the body?

8. How does the breathing of foul air (arising from want of proper ventilation) affect the milk produced, and the cheese and butter made from it? Are there any other means whereby similar impurities influence the milk?

9. How may the milking character of a cow be improved; how may the flow of milk be more permanent, and its character rendered more suitable for butter and cheese making respectively?

10. What lessons may we learn from the system of farming known as "the continuous growth of corn," and what are the essentials for its success?

Thomas Murby, Educational Publisher.

WRITING.

The Imperial Copy Books. Adapted to the Standards of the Code. Standard I., Nos. 1, 2; Standard II., Nos. 3, 4 Standard III., Nos. 5, 6; Standard IV., Nos. 7, 8; Standard V., Nos. 9, 10; Standard VI., Nos. 11, 12. Price 2d. each. Large Post Edition, stiff nonpareil covers, superior paper, 3s. 6d. per dozen Six Books now ready.

The Excelsior Copy Books. Nos. 1 to 13. Adapted to Code, 1877. Standard I., Nos. 1, 2, 3; Standard II., Nos. 4, 5, 6; Standard III., Nos. 7, 8, 9; Standards IV.—VI., Nos. 10, 11, 12, 13. Price 1s. 4d. per dozen (nett).

The Address Copy Book; or, How to Direct a Letter. Fortieth Thousand. Books I. and II., 2s. 6d. per dozen.

First Standard Writing Cards. Cards 1, 2, 3. Price 6s. per gross.

MURBY'S SCIENCE AND ART SERIES.

[Edited by SYDNEY B. J. SKERTCHLY, F.G.S., H.M.'s Geological Survey.]

Physical Geography. New and Enlarged Edition, embodying the results of the "Challenger" Expedition, also containing a new Chapter on the Distribution of Animal Life, and a series of Questions for Examination on the whole work. By the EDITOR. 1s., cloth.

Simple Lessons in Physical Geography. For Reading Classes. Standard IV., price 2d. Standards IV., V., and VI., price 6d.

Geology. By the EDITOR. 1s., cloth.

Botany, Structural and Physiological. By ALFRED GRUGEON. 1s., cloth.

Simple Lessons on Botany. For Reading Classes. By G. T. BETTANY, M.A., Lecturer on Botany at Guy's Hospital. Price 4d.

Crystallography, with Coloured Diagrams, from which handsome Models of the principal Crystals may be readily constructed. By JAMES B. JORDAN, of the Museum of Practical Geology. 1s. 6d., cloth.

Mechanics. 1s., cloth.

Hydrostatics, Hydraulics, and Pneumatics. 1s., cloth.

Natural Philosophy. The two preceding vols. in one. Price 2s., cloth.

Inorganic Chemistry. By R. MELDOLA, F.C.S., Late of the Science Examining Schools, South Kensington. Non-Metallic Elements, 1s., cloth.

Inorganic Chemistry. The above volume with the addition of the Metallic Elements and Chapters on Analysis, 1s. 6d., cloth.

Qualitative Analysis. For Laboratory Practice. By J. SPENCER, F.C.S. 1s., cloth.

Mineralogical Tables, describing the Physical and Chemical Properties of all the important Minerals. By F. NOEL JEWESBURY, B.A., Caius College, Cambridge. 1s. 6d., cloth.

Mineralogy. By F. RUTLEY, F.G.S., H.M.'s Geological Survey. 1s. 6d., cloth.

Projection, or Practical Solid Geometry. By J. PAYNE, of the School of Science, Charterhouse. New and Enlarged Edition, with Questions for Examination on the whole work. 1s. 6d., cloth.

Animal Physiology. By E. T. NEWTON, F.G.S., Assistant Naturalist to H.M.'s Geological Survey. 1s., cloth.

Simple Lessons in Animal Physiology. For Reading Classes. By G. T. BETTANY, M.A., Caius College, Cambridge. 4d.

The Connection of Geography and Astronomy. By Dr. A. H. DICK, D.Sc. (Edin.), M.A., LL.B. (Lond.), F.R.G.S., Author of "Elementary Geography for Schools." Price, cloth, 1s. An essential companion to most School Geographies.

Plane Trigonometry. A Complete Elementary Course, with numerous Exercises. By J. HENCHIE, Medallist in Mathematics, and Mathematical Master of the United Westminster Schools. 160pp. Price 1s. 6d., cloth. New and Revised Edition.

Principles of Agriculture. By A. CAREY, Head Master of Board School, North Tawton. Price 2s.

LONDON: 32, BOUVERIE STREET, FLEET STREET, E.C.

MURBY'S SCRIPTURE MANUALS.

Intended to supply, in a compact form, the requirements of Students getting up the several Books of the Bible for examinations.

Old Testament History.

Genesis	6d.	First Book of Samuel .	6d.	Ezra, Nehemiah, & Esther (in one) . . .	6d.
Exodus	6d.	Second Book of Samuel .	6d.	Chronicles II. . . .	9d.
Numbers	6d.	First Book of Kings .	6d.	Jeremiah . . .	6d.
Joshua & Judges (in 1 vol.)	9d.	Second Book of Kings .	6d.		

New Testament History.—Gospels of

St. Matthew . . .	6d.	St. Luke, New Edition	9d.	Acts of Apostles . .	9d.
St. Mark . . .	6d.	St. John	6d.		

The Book of Common Prayer. A Manual Historical and Explanatory. By J. B. GRIFFITHS, B.A., St. John's College, Cambridge, Whewell's Scholar of International Law. To this work 36pp. of Supplementary Notes have lately been added. 140pp., price 1s.

The Church Catechism Explained and Illustrated, and its Truths Enforced by Scripture References. By WILLIAM MARIGOLD, Master of the Fairford Endowed Schools; revised by the Rev. JOHN HOPTON, M.A., Prebendary of Hereford Cathedral, and Vicar of Canon Frome. 3d., sewed. Enlarged Edition, to which 32pp. have been added, cloth, 6d.

ENGLISH HISTORY.

Analysis of English History. A Text Book for Colleges and Schools. By W. C. PEARCE, and S. HAGUE, LL.B. New Edition. Price 1s. sewed 1s. 6d. cloth; or with the Biographical Appendix, 1s. 3d. or 1s. 9d.

Biographical Appendix. By the Author of "Murby's Scripture Manuals." Paper covers, 4d.; cloth, 6d.

Murby's Junior History of England. A Reading Book and Text Book for use in Schools. Price 1s. Illustrated.

The Scholar's Home Lesson Book of English History. A condensed Epitome of English History, chronologically arranged, and subdivided into daily lessons. By W. C. PEARCE, joint author of "The Analysis of English History." 66pp., price 6d.; or in two Parts. Part I., Julius Cæsar to the Wars of the Roses, &c. Part II., Henry VII. to Victoria. Price 2d. each.

The Chronological History of England. With copious Notes, for use in Schools. By LOUIS B. ABRAHAMS, B.A. 36pp., sewed, 4d.; cloth, 6d.

Simple Lessons in English History. For Reading Classes. By W. C. PEARCE. For Standard IV. 40pp., price 2d.; for Standards IV., V., and VI., 112pp., price 6d.

GEOGRAPHY.

The Geotrope: a Model showing the motions of the Earth, &c. Price £2 2s.

Elementary Geography for Schools. A First Book of Political, Commercial, and Historical Geography. New Edition, embracing the results of the Berlin Congress. By A. H. DICK, D.Sc. (Edin.), M.A., LL.B. (Lond.), F.R.G.S. Price 1s. 6d.; Cheap Edition, 1s.

Murby's Geography and Atlas, consisting of the above work, and a Selection of Sixteen beautifully engraved and coloured Maps (size 6in. by 7½in.). 2s., cloth boards.

The Connection of Geography and Astronomy. By Dr. A. H. DICK, D.Sc. (Edin.), M.A., LL.B. (Lond.), F.R.G.S. Price, cloth, 1s. An essential companion to most School Geographies; just contains what they omit.

Great Britain and her Colonies. From Dr. Dick's Geography for Schools. 96pp. Price 8d.

The Scholar's Home Lesson Book of Geography. By W. C. PEARCE. 6d. cloth. Standard II., 1d.; Standard III., 1d.; Standard IV., 2d.; Standards V. and VI., 2d.

Penny Geography of the World. Price 1d.

Easy Lessons in Physical Geography: For Reading Classes. Standard IV., price 2d.; Standards IV., V., and VI., price 6d.

Aids to Accuracy. Tables of History and Geography for frequent repetition. By S. CROFT. With Introduction by Canon GREGORY. New Edition, price 9d.

County Geographies, with Maps. Middlesex, Lancashire, Yorkshire, Norfolk, Staffordshire, Surrey, Devon, Kent, Glamorgan, Lincoln, Nottingham, Warwick. Price 2d. each.

LATIN AND FRENCH.

An Easy Elementary Course of Latin. Being a series of works of a progressive character, and in bold type, for simplifying and expediting instruction in Latin. By William Dodds. Revised by J. R. Morell, formerly one of H.M.'s Inspectors of Schools. Book I.—Contains the declensions of nouns and the prepositions. Book II.—The adjective and pronoun. Book III.—The conjugations of verbs. Book IV.—Irregular verbs and indeclinable parts of speech. Price 6d. each part; or complete, cloth, 2s. Key, 6d.

The Poetical Latin Reader. Selections from Ovid, with Notes and Vocabulary. By C. Bilton, B.A. Price 2s. 6d.

Le Petit Tresor. An Easy First French Grammar and Reading Book. Price 6d.

REGISTERS.

Register Card of Attendance and Progress. Price 1d.

The Treasurer's Cash Book. (50 leaves), 4s. and 6s. 6d.; (100 leaves) 5s. and 7s. 6d.

The Crown Register of Attendance and Fees. By J. S. Horn. Price 1s. Specially adapted for Schools under Government Inspection.

DRAWING.

Ancient and Modern Vases. By J. Wadey. 24 in a set. Price 1s.

Murby's Freehand Examples, Designed by W. A. Smith, Certificated Master of the Department of Science and Art. 24 designs, size 15in. by 10in. To be copied by a whole class simultaneously. Price 2s. per set, plain; or 5s. on cards and with rings.

Curvilinear Freehand Copies. Grade I. By J. Wadey. 24 Large Cards. Price 2s.

Curvilinear Freehand Copies. Grade II. By J. Wadey. 18 Large Cards. Price 2s.

The Young Artist. A Monthly Instructor in Drawing and Design. Nos. 1 to 12. Price 2d. First Yearly Volume, stiff covers, 2s.

MUSIC FOR SCHOOLS.

Now Publishing.

What Shall we Sing? A Selection of Part Songs in the Staff and Tonic Sol-fa Notations. Edited and composed by Thomas Murby. Issued in Numbers, ½d. each; and in Parts, containing Twelve or more Songs, at 6d.

The Musical Student's Manual. A Theoretical and Practical Treatise on the Elements of Music, and the Practice of Singing at Sight. By T. Murby. Crown 8vo, 228pp., cloth, 3s. 6d.

Murby's Introductory Manual of the Theory of Music. Part I., price 6d. This little work is issued for the assistance of pupils preparing for examination in Music, either at the Oxford and Cambridge Local Examination, the Queen's Scholarship or Certificate Examination, or for those given by the Science and Art Department, South Kensington.

New Tunes to Choice Words. A Collection of simple Part-Songs, chiefly original, for Schools and Homes. Books I. and II., each containing Thirty-two Pieces, cloth, 1s. 6d. each.

The Juvenile Tonic-Sol-Fa Part-Song Book. Uniform with Curwen's Tonic-Sol-Fa Reporter. Second Edition, price 3d., in stiff covers. By Henry Ball, Head Master of Royal Lancasterian Schools, Manchester; and George Thornley, author of "The Choir," "The Scholar's Hymn and Tune Book," &c., &c. A collection of 40 songs, arranged in three parts, in the Tonic-Sol-Fa Notation, for the use of Schools.

The Merry-Go-Round. A collection of Rhymes, Jingles, and Songs, for the amusement of the little ones. By Thomas Murby. 1s. sewed, 1s. 6d. cloth.

Murby's Melody Piece Book, the Best and Cheapest School Tune Book. A Collection of 131 Favourite School Songs, Rounds, &c. Words and Music, price 6d. Also in Two Parts, 3d. each. Compiled by the Rev. W. J. Denman, Rector of Stoke-by-Clare, Suffolk. Music revised by Thomas Murby.

The Lord's Prayer, set to Music for the opening or closing of School. By T. Murby. 1d.

Singing at Sight. By E. W. Searle. In two Parts, fcap. 4to., 6d. each.

*** Schools supplied with all kinds of School materials, Stationery, and Furniture, at Wholesale Prices. See Miscellaneous Catalogue. The Publications of other firms supplied on Wholesale Terms.

LONDON: 32, BOUVERIE STREET, FLEET STREET, E.C.